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GEOGRAPHY AND REGIONAL PLANNING [1]

J. Lewis Robinson, M.A., Ph.D.

President of the Association, 1955-56

We, as geographers should be interested in the practical applications of our subject. The Canadian Association of Geographers has in its membership both academic and professional geographers. This paper presents comments on some ways in which our academic subject, geography, can be applied to a particular practical field, namely regional planning.

Although I now wish to emphasize the use of geography for professional work, I do not forget that as an academic subject, geography has a very important contribution to make towards educating our youth and adults in "World Understanding". We should not forget that geography describes and explains areal relationships in the world around us, and as such is a "cultural" or teaching subject.[2] Interest in geography will continue to increase in our colleges and universities if it is properly taught as a vital, alive subject dealing with people and regions that we can read about, or see on TV, and not as a dull collection of statistical and encyclopedic facts. But as this interest is aroused in young people, there are many who are, and will be, entering geography honours and graduate courses, who will not be interested solely in becoming teachers of geography to the next generation, but who will want to know the practical applications of geographical principles. We often hear convocation speakers who bemoan the declining value of an Arts education in this professional and scientific world, and I hope that geography never becomes a subject which is taken purely because it can lead to a job.

Geography was almost entirely an academic subject prior to 1940, but after World War II, it became increasingly a professional field. It is the task of academic geographers both to broaden and to point our university philosophy and training so that young geographers can make, or find, opportunities in government and industry to "practise their trade" as professional geographers. This duty carries with it the two-fold responsibility of educating the non-academic person - and future employer - to the practical value of a geographical education, and also stressing the applications of our principles to our students.

Much has been written about the rapidly increasing population of Canada, and the problems of using our "untold natural resources" wisely. Persons from all fields have pointed out that if we plan widely and well, Canadians can use these resources to have a good life in pleasant surroundings. It seems to me, however, that too many people are too busy "doing things" to do much planning. The skill and optimism which we have developed in being able "to do the impossible" on this continent, is often taking precedence over consideration and planning for the future. I also believe that much of what is being said about planning in Canada is overlooking the valuable contribution which a geographical approach, and a properly-trained geographer, can make towards successful planning. If planning means "to provide the utmost in

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[1] Presidential address delivered at the Sixth Annual Meeting of the Canadian Association of Geographers, Montreal, P.Q., 1956.

[2] Brouillette, B.: "The Role of Geography in General Education", The Canadian Geographer, 6, 1955, p.1-5.

human occupance of the land", then planners must have to deal with relationships between people and the land - these relationships we state are one of the basic principles of geography. If planning can be called "arranging the geography of to-morrow", then geographers should know something about it.

In order to apply geography towards problems of planning, it is first necessary that non-geographers know what modern geography includes. Many municipal and regional officers who will become concerned with organizing and recruiting planning staffs may come from a generation who knew geography only as a dull grade school subject. Geographical philosophy is not new, but the way in which it is now being taught in Canadian universities is new. One definition states that it is "the study of the influences of the natural environment upon man - a study of the relationships which exist between man and his natural environment". Geography is therefore firmly rooted on the earth - it studies the natural environment of that earth, which includes landforms, soils, vegetation, drainage, and climate. These forms are studied not in themselves, but for their relationships to one another, and for their influence upon man and his activities. The distinct contribution of geography is that it studies the "wholeness" of these natural conditions.

It is true that there are other specialists who deal with parts of the environment. The agriculturist deals with soil, the forester with vegetation, and the geologist with landforms. The geographical approach, however, sees the control of bedrock geology upon landforms, the effect of landforms upon climate, the influence of climate upon vegetation patterns, and so forth. These natural conditions work together in a region and it is the task of geographers to study and show these interrelationships. Since what we do in any region is greatly influenced by the character of our local environment and what it offers, it should be apparent that this geographic approach to man's problems may be able to offer a few different concepts. It is a planning principle that man must work with Nature. I am simply emphasizing that it is a principle of geography that has been taught for more than a hundred years.

If the wisest use is to be made of existing resources in a region then the interaction of the forces governing resource development must be studied. Since geographers have been trained to look for these interrelationships, and have familiarity with the language of the specialists such as forester, agriculturalist, or engineer, they should prove valuable as coordinators in regional analysis. A geographer should be more, however, than just a coordinator, or a report writer, important as these tasks are; I believe that geographers with the proper personality, would make the best administrators of a planning region. Broad understanding plus a knowledge of several detailed techniques are attributes needed in an administrator, and geography gives this background.

Regional studies are a basic theme in much geographic work. Although regions may be studied for themselves, they cannot be studied apart from other regions. Thus it is, that in planning the geographer can study any part or function of the region and see its place or position in the larger region. This ability of being able to deal with local problems, and not to overlook their larger regional implications, is an important contribution of the geographer to regional planning. This is not to say that geographers have been interested in regions for the sake of planning. Rather, geographers have been concerned with regions as such, because the regional concept is basic in describing and interpreting the varying patterns of the earth's surface.

Regional studies are practical and flexible, because geographers deal with a hierarchy of regions from small to large, from local to national.[1] Our purpose is to

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[1] Whittlesey, D.: "The Regional Concept and the Regional Method", Ch. 2 in American Geography, Inventory and Prospect, ed. by P. James and C. Jones, Syracuse University Press, 1954, p.19-68.

understand the "personality" of the region. A small region can be studied like a close friend whom we know intimately. A medium-sized region is like a person in the neighbourhood, about whom we can learn many things, but time does not permit full understanding. Planning must deal with "man-size" regions, because man is not capable of encompassing large areas into his knowledge in detail. There can be a "Geography of British Columbia", or a "Plan for British Columbia"; each would have to be general in nature until it was subdivided into smaller regions and sub-regions. To understand the "Geography of B.C." one would have to understand the nature of each of its sub-regions; a "Plan for B.C." would work best if there were also plans for each region or part of B.C.

Planning has to take place at several levels, from local to national, and the geographer is at least equipped to think regionally at several levels. He realizes that whatever the size of the region, it can be analyzed for itself, but it cannot be separated from larger regions. The geographer is also conscious of the fact that regions are defined for certain purposes and that a change in purpose or definition may give rise to a change in regional boundaries. He should, therefore, be able to formulate plans that are flexible enough to allow for any such boundary change. I realize that some of the main problems of planning are those dealing with legislation and administration. I believe that geography can assist by presenting objectively the inter-relationships among phenomena, and therefore pointing out the conflicting interests that will always exist in a region. The solution of many of these conflicts is usually beyond the scope of geography, since they require legislation, but geography can present the ramifications of the problem.

In a regional study the purpose should be to point out the interdependence of the people and the land and its resources. Geographers use a fairly standard method of approach in regional analysis. This method will fit either urban or rural regions, large or small, although the particular topics may receive more or less emphasis,depending on the character of the region.

The geographer normally deals first with natural conditions, or the "physical environment". He studies bedrock geology, landforms, drainage, climate, vegetation patterns and soil distribution in so far as these physical conditions have some effect upon the occupations, transport, or general way-of-life of the region. He emphasizes the relationships between the environment and resources - geology and minerals, vegetation and forestry, soils and agriculture, drainage and power, and so forth. He can stress the interdependence and conflict in the resource uses which depend on that environment. If specialists have been used to gather the factual information on soils, vegetation, etc., the geographer can make a contribution by interpreting this information to the layman, who is ultimately the person who must understand and "be sold" on planning.

Next, a regional analysis looks at the historical growth of the area. This historical treatment should not be for historical records alone, but should seek to explain the growth of settlement patterns and the concept of changing resource-use. All geography is dynamic, and too much regional geography is taught or written as a static picture. To understand the present, and predict the future, it is necessary to see trends in "man-land" relationships. Much of this information can be shown best on maps. For example, a series of settlement maps at different historical periods can show both the direction and rate of growth. These maps could show, for example, that a part of the urban area has grown outward 5 miles in 15 years, and thus tells graphically that if conditions remain the same, suburban planning for future growth is necessary at the rate of a mile in three years in that area. In like fashion series maps can show the amount and rate of forests cut, land occupied and cultivated, or river valleys eroded.

A final step is the mapping of the present land-use of the region, A catchy definition of geography says that it studies "how much of what is where". Certainly such

an inventory of resources and peoples is necessary for planning because the existing pattern must be used to build for future development. Again, much of this information is concerned with showing the distribution of functions and occupations and resources. Both geographers and planners must think in terms of distributions, and thus both geography and planning are understood best while working over maps.

Although primary data may be gathered by any one of the specialists in other fields, geographers, themselves, have been trained to read air photos for a variety of information, and to do land-use mapping in the field. We should not over-stress our value as coordinators in regional analysis, because geographers should be able to describe and interpret the environment of the region. Geographers should be field workers and towards this end we need more and more thought about the improvement of field methods and about our survey methods for gathering regional data.

Since the geographer's tools are maps, he is able to show graphically and simply the distribution of many social and economic factors which influence the development of a region. Statistics come to life and have meaning when shown on distribution maps of, for example, population density, nationality, income, occupations, and so forth.[1] The geographer compares these maps and looks for relationships. If the same factor is repeated in the same place, there may be some cause and effect relationship.

The task of reducing the distribution patterns of the region to a size best suited to critical appraisal and comparison requires knowledge and experience at how to make a map "readable". Planners may argue that any draughtsman can make maps, but geographers are doubtful. The difference between draughting and cartography is one of design. There are good and poor ways of showing the same information on a map. The right way requires knowledge of what a map can and should do, and skill in making the information show what it is supposed to show. Such knowledge and skill are more likely to be obtained from a cartographer who has studied maps from the first step of selecting a proper projection, through the intricacies of design, to the final stage of map reproduction methods.

Every layman believes that he can read a map, but how many good regional plans lie dormant because the public could not understand the maps? It is important to the planner that his plan be presented in the simple, direct language of good maps, so that the plan which has value for the future can be accepted. Plans are made to be implemented, and not simply to employ planners'.

In the many regions where growth is taking place in Canada, it is obvious that regional planning is needed. To be practical, a plan must have a scale. That is, what is the future population of the region which is being planned? What will be the occupations of the people in this region? How much space will they require for housing? Too often the future size of a region is calculated by an individual with sound mathematical training who plots the region's past growth on a graph and then projects this curve into the future. Such a graph may overlook entirely the functions and resources of the region. The people of a region are largely supported by local resources, although admittedly, other resources of a broader hinterland may be brought into the region for processing. But even processing is dependent upon some power resource, labour supply, harbour facility, or geographical position within the region in question. Frequently, in graphing an increased population, it is considered that all present occupations will increase in the same ratio. This concept is <u>not</u> valid unless it is shown that the regional resources upon which the occupations depend are also all capable of expansion at the same rate. Such is seldom the case, for many regions have only a few resources the use of which might be expanded and others may already be utilized to near their maximum under present technology.

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[1] Mackay, J. Ross: "Geographic Cartography", <u>The Canadian Geographer</u>, 4, 1954, p. 1-14.

In analysing the future population growth of an area, a geographer should study the regional environment. This environment offers certain resources, which can be compared with similar environments and resources which the geographer knows in other parts of the world. Such regional studies which geographers have been carrying on throughout the world permit us to compare and contrast our region and its problems of resource-use with other regions. If the mapping and analysis of the local environment indicate that expansion is probable and desirable, it is possible not only to predict the trend of future population increases, but also to indicate the occupation groups which should show greatest growth.

Too often administrative officers who lack a geographical background think of area purely as the space occupied within political limits, without carefully analysing the character of that area. There are areas that are physically suited to particular functions and other areas which are not. We are aware that there are at least four main functional zones within a region, namely those of residential, commercial, industrial and recreational uses. As indicated previously, the expansion of these particular functions should not be expected to be uniform, and their growth will be related to the resources of the region. If such is the case, the regional analysis may indicate that the industrial areas should expand at a greater rate than the commercial functions. Planners then should analyse the type of area that is available or desirable for industrial growth. Such sites are usually limited in size and position, since they require to be along transportation lines or accessible to transport extensions. In addition, industrial sites are rather particular as to physical conditions of bedrock, topography and drainage, since factories are usually less adaptable to site than are residences or stores.

In many of our expanding suburban areas in Canada the regional concept seems to be ignored when it comes to the location of new residential areas. I refer specifically to the expansion of housing into excellent agricultural land around many of our large cities. Although we still have several thousands of acres of unused arable land in Canada, we know that much of this land is not of good quality.[1] Some of our best lands, and those being intensively utilized because of their location, are near our large cities which are now in the process of rapid areal expansion. In British Columbia - a land of limited agricultural resources - we can see how the suburban sprawl of Greater Vancouver is rapidly devouring the excellent delta soils and dairy lands at the mouth of the Fraser River. And this is happening despite the fact that there are poor glacial soils on the uplands still unoccupied and which have excellent view locations for housing.[2] This same example of dwindling arable lands is repeated outside of Greater Victoria and in parts of the fruit-growing regions of the Okanagan Valley. It is seen also in many places in Eastern Canada, notably along the lake shore of western Lake Ontario. All planning ultimately faces the problem of deciding which of the multiple-uses possible is the proper one. I maintain that the geographer's experience in balancing relationships and studying the multiple use of resources, equips him to make these planning decisions for the good of the region.

The regional concept is useful and valid in planning because it encourages the planner to see the whole and each of its parts. Regional planners may become lost in

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[1] Putnam, Donald F.: "Geographical Factors in Canadian Planning", Revue Canadienne de Geographie, 7, 1953, p.64-71.

[2] Robinson, J. Lewis: "Planning for Agriculture in B.C.", Proceedings of 6th Regional Conference, B.C. Division, Community Planning Association, 1953, p.10-13.

the trees and not see the forest. They are involved in slum clearance, sewer plans, bridge crossings, locating industrial sites, and the like - all of which are necessary - but they may not see the grand scale, the regional plan. Do they know the geographical concept of the "city-region" - i.e. the relationships between the city and the hinterland which supports it, and which the city in turn services? Do they see the total regional environment and the many influences which the environment has upon man, his occupations and activities? Finally, do they understand regional geography, - the analysis of the physical environment and resources of a region - which can be applied in several directions, and specifically as a basis for proper regional planning?

Both geography and planning have many principles and methods in common. No successful plan can be based on preconceived ideas of what is best for the region. It must be a plan which fits its physical setting, its historical development, and adjusts to the present patterns. Planning is regional geography projected into the future, with the hope of guiding the region into desirable patterns in harmony with its environment.

In this discussion, I have referred very little to city planning or urban geography. This is partially because the omission of the topic could be justified by the title of the paper, "Geography and Regional Planning", but more significantly, because I believe that geographers have played a less important part in city planning. There are some notable exceptions to this statement, and I am sure that there can be more work done in this field in the future. A city is simply another kind of region, occupying a small space, and many of the principles of regionalism also apply to cities.

It was natural that architects and builders should be among the first to be concerned with city design and planning and they have continued in that role to the present day. Urban geographers are interested in cities from several different approaches, and can thus make significant contributions to city planning. Since geography deals with area, one of the purposes of urban geography is to seek to understand the relationships between the functions of a city and the total area which these functions occupy. Urban geography, like all geography, should be firmly planted on the earth and should show how the city and its people are related to the land and resources of the surrounding hinterland. We should remind planners that cities are the core areas of regions.

I feel less confident about the movement of geographers into city planning, in contrast to regional planning. Whereas we have an academic philosophy of regionalism which can be applied and used in regional planning, I find few examples of principles in urban geography. We have no good textbooks on the subject. Many of the periodical articles on cities are examples of specific functions or activities, but they seldom illustrate principles with wide urban applications. It is true that city planning can use many of the tools and techniques of geography, and of course is doing so, but I think that our students entering city planning as professional geographers would be better prepared if they came armed with a sound philosophy of principles of urban geography. I doubt if we are supplying these principles.

In regional analysis, geographers usually deal with agriculture, forestry, recreation and other resources which they study under the broad topic of "Economic Geography". In urban planning, there are many problems of municipal finance, zoning legislation, engineering problems, traffic flow and the like which are often not in the allied courses of study of geography honours or graduate students. Whereas I feel that the step from regional geography to regional planning is an easy and logical one for geographers, I would like to caution our academic groups to step warily as "applied urban geographers" into city planning. I wonder if we are giving our geography students the proper training for such duties? I do not know that architects, engineers or sociologists are obtaining any better training, but I doubt that we are doing our best in this field, and we would be wise to take careful stock of our training and its value to city planning work.

Along the same line of self-analysis, are we doing our best at the academic level to promote regional thinking and analysis? If you can agree with me that regional

planning can be an important profession for geographers, then we should look carefully at our geography curriculum to see if we are preparing our students for this field of work. All geography departments must be feeling the strong double-pull which is sometimes from opposite directions. On the one hand, we have a growing awareness of geography as a teaching subject in the schools, valuable to a general education, and therefore the necessity to give courses which will be helpful to teachers and future teachers. On the other hand, we have an increasing number of graduate students who want to make geography a "professional" field, and who definitely do not want to teach. As a generalization, the teachers take the regional courses by continent, or parts of the continent, in order to learn factual information, which in turn is simplified to be taught at a lower academic level. The embryonic professional geographer stresses the systematic or technique courses such as cartography or climatology, and plans to apply these tools to problems of business, government or planning.

Although most geographers agree that the philosophy of regional and systematic geography is but part of a larger field of general geography, I suspect that the two divisions often remain separate in our teaching. We should be teaching our regional courses not as a collection of encyclopedic facts about certain parts of the world, but as a synthesis of distribution patterns which illustrate the "personality" of the area in question.[1] A student who is trained in this type of regional thinking can use these principles to make regional studies of his own for planning purposes, or he can also use the information and approach to be a good teacher of regional geography. We know that good regional geography is not separate from systematic or technique geography, but is actually built upon it. There is no reason why our regional courses should not contain systematic studies of climate, settlement patterns or resource development, and at the same time be using our geographic techniques of field survey and cartography. My point is that geography departments need not be caught in the dilemma of opposing pulls from academic and professional students, but can serve both by teaching proper regional studies and analysis.

If the philosophy and techniques of regionalism are basic to geography and are understood by our students, there can be many applications of it. "Area research" is needed in the business world, and is background in marketing geography. Large-scale industry thinks of "supply areas" and "selling areas". Regional or area thinking is by no means unique to geography, but we should be able to train students to think regionally better than any other discipline. The student with initiative can apply it to professional work. To come back to the main theme of this paper - in this busy life of specialists, somewhere we need the planners with broad vision and regional viewpoint, who can assist and direct us, so that our work fits together for the common good. Geography, properly applied, gives this viewpoint and breadth.

Geographers are, of course, not the only people who will be concerned with planning, but their work emphasizes one of the themes of this paper - that geographers are interested, and I believe qualified, to be active in regional planning. Professional geography is still young in Canada, and in the past few years there have been more positions open in teaching and government service than there have been qualified geographers to fill them.[2] As we train more and more geographers in Canada, I would hope that many would continue into the planning field, in which, at present, there is a notable lack of trained personnel. Planning must be done in Canada if we are to use our area and resources wisely and properly, but because of

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[1] Scarfe, Neville: "The Teaching of Geography in Canada", The Canadian Geographer, 5, 1955, p.1-8.

[2] Robinson, J. Lewis: "The Development and Status of Geography in Universities and Government in Canada", Yearbook of Association of Pacific Coast Geographers, 13, 1951, p.3-13.

the wide diversity of environments in Canada, such planning must be on a regional basis to be effective. Geographers have the background and viewpoint to contribute to this future regional planning.

Geography is already playing an active part in planning organizations in Canada and in other parts of the world. At four universities in Canada there are now graduate courses in Community and Regional Planning, which have been assisted financially by grants from the Federal Central Housing and Mortgage Corporation. At two of the universities at least, namely McGill and U.B.C., geography is part of the subject matter of the course, and through which comes a good share of the graduate students. Some university geography staff members have demonstrated their interest and concern in planning by being members, and on the regional Executives, of the Community Planning Association of Canada.

In Ontario, geographers have been employed by the Department of Planning and Development, and have played a part in the valuable River Valley Authority studies which have been carried out by the provincial government. Geographers have also contributed their techniques to city planning departments. Saskatchewan is one of the leaders in Canada in the employment of geographers at the administrative level, and in particular in the planning of proper resource-use. There we have one of the best examples of the practical and applied advantages of geographical training and viewpoint. In Alberta, geographers are employed by the Community Planning Division, Department of Municipal Affairs. In British Columbia, geographers have prepared many of the reports, and do much of the research, for the two Regional Planning Boards in the Lower Fraser Valley and in Victoria, and also for the Fraser River Basin Board. Geographers also do planning work for Provincial Parks, and for the Department of Municipal Affairs in the provincial government.

In conclusion, may I repeat what I have said earlier in other words. Geography is <u>not</u> necessarily planning. Planning is cooperative and regional effort. It requires the skills and energies of many persons in many walks of life. I have stressed the geographer's part in planning because I believe that he has made, and can make, a contribution, and that many may not be aware of this because of the new concept of university geography. I have <u>not</u> said that regional geography is the final answer to all regional planning. It does, however, have a sound approach which merits understanding and consideration. Whatever we do, however, we should realize that geography is now both an academic subject and a professional field, and we cannot afford to neglect either. Geography must continue to play its part in educating future generations in the "ways of the world", for our very survival now depends on the sincere understanding of the lands, peoples and problems of different parts of the world. At the same time geography can contribute to the understanding and planning of local regions so that our lives can be more comfortable and pleasant as we live together with Nature.

ADDITIONAL NOTES ON MUD CIRCLES AT RESOLUTE BAY, NORTHWEST TERRITORIES [1]

Frank A. Cook

United College, Winnipeg

During the three consecutive summers of 1953-55 detailed excavations were made of fifty mud circles at Resolute Bay, Cornwallis Island, Northwest Territories, latitude 74° 41' N., longitude 94° 54' W., and a considerable intimacy achieved with this particular periglacial phenomena. This paper presents some of the quantitative findings, as well as qualitative observations. It is additional to Mackay's paper [2] and acknowledgment is made here of valuable advice received from him in the early stages of research.

Historical

As in the field of cryopedology [3] generally, considerable confusion exists in terminology as applied to individual forms of patterned ground.

Washburn in his basic paper [4] on patterned ground refers to mud circles as one form of nonsorted circle. Whereas there is an excellent plate showing his nonsorted circle, [5] there does not appear to be much discussion in the text. However, his reference in the text to sorted circles [6] with accompanying plate would appear to be the mud circles as described by Mackay and studied by the writer.

Washburn, on exhumation of these circles, found cohesive columns of gravelly material containing a much larger percentage of fines than the adjacent gravel. The better formed columns had a distinctly longer vertical than horizontal axis and approached a circular form. Commonly the longer axes of stones occurring within the columns that lay beneath the surface were oriented parallel with the sides and top of the column and were particularly tightly packed at the top. The core of the columns generally contained a higher percentage of fines than the margins. Although the cores had a diameter of some 10 to 20 cm., the upper part of those that extended to the surface appeared to spread out with the fines disseminating into the surrounding beach gravel.

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[1] Presented at the Sixth Annual Meeting of the Canadian Association of Geographers in Montreal, 1956.

[2] Mackay, J. Ross: "Fissures and Mud Circles on Cornwallis Island, N. W. T.", The Canadian Geographer, 3, 1953, pp.31-38.

[3] Cryopedology is used here as meaning the study, both theoretical and practical, of intensive frost action and permanently frozen ground. (Bryan, Kirk: "Cryopedology - the study of frozen ground and intensive frost action with suggestions on nomenclature", American Journal of Science, 244, 1946, pp.622-642).

[4] Washburn, A.L.: "Patterned Ground", Revue Canadienne de Géographie, 4, 1950, pp.5-54.

[5] Ibid., p.14.

[6] Ibid., pp.35-37.

Mackay[1] applied the Davisian concept of youth, maturity and old age to the development of mud circles. In youth they are represented by plugs beneath conical pits. As the mud circles arise, or are injected upward, they increase in size and eventually break into the pits, generally on the sides that are toward lower altitudes. At this stage maturity may be considered to have commenced. The mud plugs gradually push up until they fill the depressions and may even build convex mud 'pies' above the general beach level. As more and more plugs reach the surface they begin to coalesce, at which stage old age may be considered to have set in. Individual plugs may eventually lose their identities as they merge to form other types of patterned ground.

Both Washburn and Mackay thought that these circles could be explained best by the cryostatic hypothesis of origin of patterned ground. In the cryostatic hypothesis, as first stated by Washburn,[2] debris is thought to be squeezed between downward freezing ground and the permafrost table. Upward injection would take place in the area of easiest relief. Once a mud plug began to rise a number of factors operate to continue it, one being that the mud plug remained unfrozen longer than surrounding gravel and thus had more mobility.

Location

In the summer of 1953 an intensive reconnaissance survey of patterned ground in the immediate vicinity of the Resolute Bay Ionosphere station revealed that mud circles were the most accessible type for detailed study. An area of several thousand square feet was selected, in which mud circles, numbering into the hundreds, were plastered along the contours of two consecutive beach lines and in the intervening swale.

The mud circles were in a stage of late maturity and their distribution was similar to those mapped by Mackay[3] in 1952. They sometime aligned themselves in rows on the downslope side of transverse fissures, in which case they could touch one another, or remain spaced several feet apart. At several "T" junctions between transverse and longitudinal fissures, or where longitudinal fissures bifurcated at angles greater than 60 degrees, they were found both around and within the junction. On horizontal ground without fissures they were found both in isolated positions and in coalescing networks. In surface expression the mud circles were essentially circular, and a count of 400 in the area under study gave an average diameter of 15 inches, with 82 per cent falling within the modal group. In isolated positions, however, they were somewhat smaller, averaging 12 inches in diameter.

Field Data and Technique

Preliminary digging showed that when the surrounding regolith was shovelled away the mud plug was cohesive enough to stand alone in the hole permitting it to be dissected, providing extreme tenderness was used when working on it. The techniques of till fabric analysis as developed by Chauncey Holmes[4] were modified to suit the situation. Holmes' work was a study of the arrangement of component materials in

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[1] Mackay: op. cit., pp. 35-36.

[2] Washburn: op. cit., pp. 30-35.

[3] Mackay: op. cit., p. 34.

[4] Holmes, Chauncey D.: "Till Fabric", Bulletin of the Geological Society of America, 52, 1941, pp. 1299-1334.

undisturbed till. He was able to demonstrate that undisturbed till had an inherent organization, and that this organization manifested itself in the tendency of embedded stones to lie so that their longest dimension or axis coincided approximately with the direction of glacier flow at the time of deposition. It had been recognized from qualitative observations that mud plugs have an inherent organization too; and that there appeared to be a preferred orientation of enclosed material within the individual plug. Accordingly, the till fabric methods were applied to determine statistically the axial direction of the enclosed stones.

It was possible to uncover the enclosed stones by carefully scraping away the fine material using an awl and brush.(Figure 1). In most instances it was necessary

Figure 1. The Tools (putty knife, brush, awl and orientometer).

to hold the stone firmly in place until its top and sides were fully exposed. Then the long-axis direction was determined by use of an easily constructed orientometer [1] (after Holmes) used in conjunction with a reference rod. The latter was a straight steel rod driven into the plug. The orientometer bar was then held above the exposed stone and parallel to the reference bar, while the scale beam was rotated until it coincided with the long-axis of the stone. The long-axis direction was read to the nearest 5 degrees interval. The trend of the short-axis direction was then taken in a similar manner.

As one of the problems was to determine whether or not shape or degree of roundness had any influence on the orientation of enclosed stones within the plug, it was necessary to classify the stones as they were removed. Here again Holmes' classification was modified to fit the situation. A survey of stones in the area showed that three shapes and three degrees of roundness would be sufficient for a classification. As 96 per cent of all stones could be classed as rhombohedroid, varihedroid or wedge-form, the classification was limited to these shapes. Rhombohedroids have

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[1] The orientometer was constructed by attaching a protractor to a frame or bar of hard wood by a screw through the middle of the protractor.

two sets of parallel or sub-parallel sides, the ends being either regular or irregular. Varihedroids have a variety of surfaces so related as to render the stone too irregular, unsymmetrical or nodular to be assigned to either of the other forms. Wedge-forms include those whose surfaces converge either laterally or longitudinally. Three degrees of roundness were recognized, "b" moderately rounded, "c" slightly angular and "d" sharply angular. The absence of well-rounded or water-smoothed stones, despite the fact the area has only recently emerged from the sea, is no doubt due to the intense frost-shattering still active in the area. Figure 2 shows the stone classification.

Figure 2. Rock Classification.
(1) Wedge-form sharply angular
(2) Rhombohedrois sharply angular
(3) Varihedroid sharply angular
(4) Wedge-form slightly angular
(5) Rhombohedroid slightly angular
(6) Varihedroid slightly angular
(7) Wedge-form moderately rounded
(8) Rhombohedroid moderately rounded
(9) Varihedroid moderately rounded

Quantitative Date Analysis

In the course of excavation a total of 1,429 stones were exhumed and classified, of which 38 per cent were rhombohedroids, and 31 per cent each varihedroids and wedge-form. Nearly half, or 44 per cent were sharply angular, whereas 38 per cent were slightly rounded and only 18 per cent moderately rounded (Table I). The varihedroids tended to be more rounded than the other classes, as would be expected for a catch-all group. The over-all angularity of the stones is likely associated with frost-shattering.

Table II shows that there is little apparent effect of shape of the stone on its angle within the plug, as all three shapes show nearly the same angle. The slight difference in varihedroids would be expected as this catch-all group was slightly more

TABLE I

Rocks Excavated Grouped by Shape and Roundness

Shape	Roundness	Total Number	Totals by Shape	Totals by Roundness		
				B	C	D
Rhombohedroids	"B" (Moderately rounded)	56	)	56		
Rhombohedroids	"C" (Slightly rounded)	193	)- 544		193	
Rhombohedroids	"D" (Sharply angular)	295	)			295
Varihedroids	"B" (Moderately rounded)	132	)	132		
Varihedroids	"C" (Slightly rounded)	197	)- 443		197	
Varihedroids	"D" (Sharply angular)	114	)			114
Wedge-form	"B" (Moderately rounded)	59	)	59		
Wedge-form	"C" (Slightly rounded)	167	)- 442		167	
Wedge-form	"D" (Sharply angular)	216				216
Totals			1,429	247	557	625

rounded than the other groups, making the difference a function of degree of roundness rather than of shape.

Table III shows that degree of roundness does have an influence on the direction of both "A" or long axis and "B" or short axis within the plug. The average angle of both axes decreases as the degree of roundness increases.

These findings add to the strength of the supposition that the plug is an injection phenomena, and that in the course of flow of fines upward, the enclosed material assumes certain orientations depending on the degree of roundness of the particle. The more angular and flatter the stone is, the more likely it will lie parallel to the side of the plug, thus offering its area of least resistance to the line of flow, much as logs in a flowing stream. Viewed in this light the process is much like confined plastic flow of an non-homogeneous material.

TABLE II

Average Angle as Function of Shape

Group	Number	Angle "A"	Angle "B"
Rhombohedroids	222	73	74
Varihedroids	181	67	72
Wedge-form	179	72	73
All stones	582	71	73

An attempt was made to estimate the comparative value of fines as against enclosed rock fragments within the plug, both by weight and by volume. Seven plugs were exhumed en masse over a period of several days and taken to the laboratory where they were broken down, separating the fines from the rock material, and then oven-dried to remove moisture.

TABLE III

Average Angle as Function of Degree of Roundness

Group	Number	Angle "A"	Angle "B"
"B" (Moderately rounded)	103	59	68
"C" (Slightly rounded)	235	69	73
"D" (Sharply angular)	244	77	76
All stones	582	71	73

Table IV shows that the plugs averaged 73 per cent fines by volume, no one plug varying greatly from the average. As the number of stones per unit volume in the adjoining material is very much greater, an important deduction can be made from this table; that is, that fines have displaced the lost stone volume in the plug, producing pressures somewhere. Table V shows that the average weight of fine material in the plug was 43.5 per cent of the total weight with no one plug varying more than 5 per cent from this amount.

TABLE IV

Volumes of Fines and Stones

Plug	Total Volume (Cu. Cm.)	Fines		Stones	
		Volume (Cu. Cm.)	Volume (%)	Volume (Cu. Cm.)	Volume (%)
1	2,318	1,677	73	641	27
2	2,964	2,054	69	910	31
3	5,144	3,806	74	1,338	26
4	3,828	2,807	73	1,017	27
5	5,070	3,808	75	1,262	25
6	4,679	3,461	74	1,218	26
7	3,685	2,653	72	1,032	28
Average			73%		27%

Though the methods used in determining comparative value of fines as against enclosed rock fragments were of necessity crude, a uniform procedure was used throughout, and it is possible to use the comparative values with some confidence. A tentative conclusion can be drawn that mud plugs within a similar environment resemble one another very closely in all respects. Once established they appear to develop in response to a natural law. Similar studies should be conducted of plugs in parent materials of a different composition to ascertain if the same conditions hold there. If studies can be made in many different materials, and of many plugs in various stages of development, a big step will have been made toward explaining the origin and development of this phenomena.

TABLE V

Weights of Fines and Stones

Plug	Total Weight (lbs.)	Fines Weight (lbs.)	Fines Weight (%)	Stones Weight (lbs.)	Stones Weight (%)
1	8.75	4.75	54	4.0	46
2	10.75	6.0	56	4.75	44
3	16.8	9.2	55	7.6	45
4	13.5	7.9	59	5.6	41
5	9.8	5.5	56	4.3	44
6	12.3	7.1	58	5.2	42
Average			56.5%		43.5%

Qualitative Observations

Mud circles are conspicuous features of the landscape because they contrast in texture and colour with the beach lines in which they lie. One striking feature is the difference in weathering between the rock fragments lying on top of the circle and those in the surrounding regolith. The rocks lying on top of the circle, generally with

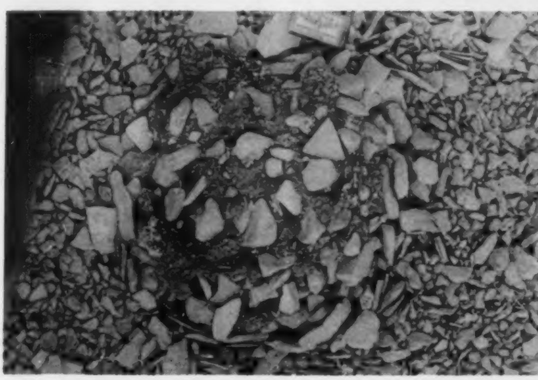

Figure 3. Mud circles demonstrating the difference in weathering between stones lying on top of the circles and those in the surrounding regolith.

no evidence of radial sorting, give the impression of having been exposed for a very short period of time as they are not solution fretted or do not show weathering. On the other hand, the rock fragments surrounding the circles have a high degree of solution fretting and show in many cases signs of advanced weathering. Figure 3 illustrates this point. In addition fresh stones were frequently found beneath the surface in the mud plugs underneath.

Another striking feature of mud circles is their apparent power to recuperate if disturbed. Nearby the area under investigation the ground had been graded with heavy equipment in 1948 during construction of the Magnetic Observatory of the Dominion Observatory. The surface of the ground at that time was completely flattened, and several inches scraped from the top of existing mud circles. The nature of equipment within the Magnetic Observatory makes it imperative that no mechanical equipment operate in the immediate vicinity, so the area has not been disturbed since. Today, only a very few years later, the mud circles are reasserting themselves. In several places there is considerable concentration of fines on the surface. In other places, there is strong evidence of doming. Once the mud circle is established, its recuperative powers must be remarkable if disturbed, for the processes working toward its development to be seen in such a short period of time. In 1952 an experiment was conducted using a huge D7 tractor. An area on a beach line containing a concentration of mud circles was graded, cutting the tops off the plugs. For several days it was impossible to tell where the plugs had been, the whole area seeming to be disturbed shattered rock and gravel. However, within a week the outline of the original circles became visible as milky water containing clay in suspension oozed out. (Figure 4). By the end of the summer there was a noticeable concentration of fines at the surface where the original plug had been beheaded.

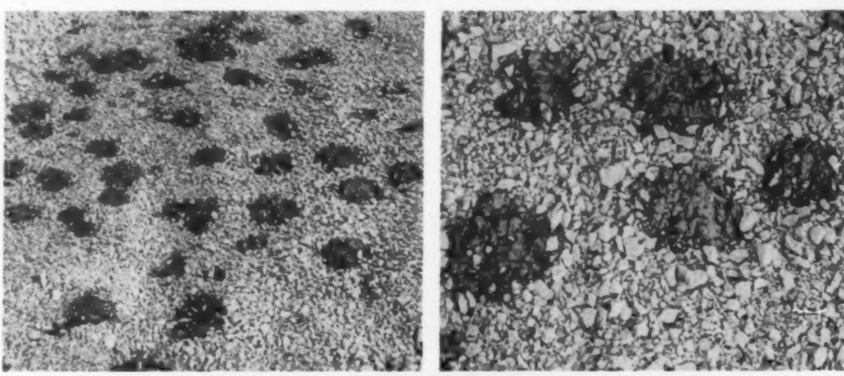

Figure 4. Beheaded mud circle oozing milky water containing clay in suspension.

The results of the experiment were so interesting it was decided to pursue the question further the following summer. Several plugs were exhumed and left standing upright in the hole after the surrounding regolith had been shovelled away. Dye was put in the base of the hole around the bottom of the plug, and into the base of the plug itself. The plugs were then examined at weekly intervals, for the rest of the summer. Within a month the dye had permeated the whole plug, and was visible on top of the plug, apparently carried there by water which was being drawn to the surface and was evaporating. The impression was gained that the plug was acting as a wick for water being released at the permafrost table, and rising through capillary action. In such a process, clay or silt of colloidal size might be carried to the surface and deposited

there when the water evaporated, thus feeding the plug and mud circles with fines from below.

Conclusions

The theory that mud circles are injection phenomena in which fines are flowing upward and spreading out at the surface is strengthened by detailed field work. There is a very high concentration of fines in the plugs underneath the mud circles giving them a cohesion not found in the surrounding regolith. The plug can become supersaturated with water, a factor influencing heating and cooling of the plug in relation to the regolith in which it is contained. It would remain unfrozen longer in summer and be more mobile than the surrounding regolith. Thus the cryostatic hypothesis may explain the mud circles, viewed not so much as debris being squeezed between downward freezing ground and the permafrost table, but as between horizontal pressure exerted from freezing regolith inward against the unfrozen debris in the plug.

In the course of flow or injection upward the material assumes certain orientations depending on the degree of roundness of the particle. The more angular and flatter the rock particle, the more likely it will parallel the side of the plug, thus offering its area of least resistance to the line of flow.

The circles in any one area seem to be very similar in all respects. Comparative studies in areas with different constituent materials, and in plugs in varying stages of development should be made to see if such is the case there.

The impression was gained that the plug will act as a wick for the passage of water upward from the permafrost table to the evaporating surface through capillary action, and that perhaps clay or silt held in suspension during the process may be deposited in the mud circle upon evaporation of the water. Further detailed study of the colloidal characteristics of fine material in mud circles, and for that matter in all types of patterned ground, are urgently needed.

PHYSIOGRAPHIC NOTES ON FEATURES IN THE MACKENZIE DELTA AREA [1]

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The Richardson Mountains confine the Mackenzie Delta on the west by a remarkably straight row of cliffs rising between two and three thousand feet above the delta. This face is strongly dissected into V-shaped valleys and interlocking spurs, broken only occasionally by streams cutting through it. The rocks are shales, sandstones and conglomerates of Cretaceous Age, the soft friable shale being the predominant member. Between the edge of the range and the delta are wide, coalescing alluvial fans, composed mainly of silts derived from these shales.

The summits of this row of cliffs are fairly concordant and there are no outstanding peaks. However, two areas of abrupt cliff faces are known locally as Red Mountain (Mount Gifford) and Black Mountain (Mount Goodenough). The latter, 20 miles south of Aklavik, rises about 2,700 feet above the delta and what appears to be a large slide of debris occurs at its foot.

Slide Debris or Glacial Deposit

This slide (Figure 1) has apparently originated from a triangular indentation in the mountain face just south of a large scalloped amphitheatre. The debris has been left as a group of knobby hills and ridges covering an area of a little more than a square mile. The hills, seldom more than 100 feet high, are covered by a relatively dense growth of black spruce, many of which are dead. The depressions are floored with a thick deposit of brownish-grey silt which is still being laid down by the small streams flowing into and through the debris area from the slopes of the mountains. (Figure 2). The age of the trees and the thickness of the silt deposits indicate that the slide is not recent. The landslide scar has been partially obscured by subsequent erosion along its slopes.

This group of hills resembles deposits of glacial drift in form and material. It occurs in an area assumed to have been glaciated. Wedges of ground ice are reported in the material. (Figure 3). However, slide debris often resembles glacial deposits and the creation of ground ice may occur as a growth in situ in areas of permafrost. A slide origin is suggested by the following observations: the scar, while obscured, may still be recognized; the hills are composed of material similar to that of the cliff; the debris overlies and interrupts a large alluvial fan which is undoubtedly of post-glacial formation; and there are no other deposits of a glacial nature in the area. The slide debris descending upon the comparatively plastic silt of the alluvial fans created waves or ripples of silt ahead of it as shown by narrow parallel ridges (Figure 1), and partly diverted the outwash stream pattern on the fan.

Silt Cover on Remnant Snowbank

The area was visited in late May, at which time most of the winter's snow had melted although remnants remained in sheltered locations. In the draws close under the precipice, in heavy willow and alder thickets, there were deep snowbanks, compacted firmly enough to walk on, the surfaces apparently serrated by wind action. The snow was covered by a quarter-inch layer of platy flakes of grey silt. This silt could

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[1] Based on field investigations carried out in 1954 while the author was a member of a Federal Inter-departmental team investigating possible sites on which to relocate Aklavik.

Figure 1. The Black Mountain area, showing the triangular debris slide scar, the group of debris hills, alluvial fans and the edge of the delta. The "pingoes" appear as tiny rings. (RCAF photo)

Figure 2. Silt-floored depression among the debris hills, showing the spruce on the hills, grasses on the valley floors. (NRC photo)

have been deposited either by water or wind, either mixed with snow or laid down on a snow surface. Spring conditions are too wet for transportation by wind. Summers are too warm for snowbanks to remain throughout the year. It seems probable that the silt was blown into these draws after the first autumn snowfall, possibly intermingled with blowing snow. The quantity of silt was sufficient to make a significant contribution to the fine material washed down the fans by normal run-off, and so illustrates the contribution by wind action to the formation of these fans.

Figure 3. Ground ice lenses in the side of one of the debris ridges. (NRC photo)

Pingo-like Features

Associated with the debris hills, three features having pingo-like characteristics were examined during the short visit. The most widely accepted theory of pingo formation is that hydrostatic pressure in a subsurface layer of unfrozen soil confined by frozen layers forces a mixture of water and fine materials upwards through a rupture in the upper permafrost layer. In the long peninsula northeast of the Mackenzie Delta, where pingos are abundant, they occur in most cases in shallow ponds or old lake beds.[1] Therefore it appears that their formation requires fine homogeneous material saturated with water.

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[1] Stager, J.K.: "Progress Report on the Analysis of the Characteristics and Distribution of Pingos East of the Mackenzie Delta", Canadian Geographer, 7, 1956. pp. 13-20.

This requirement is met in the area of the hills under Black Mountain. Spring run-off in particular brings down much silt from the lower slopes of the mountains and spreads it in the depressions between the hills. This material has a high water content and there are some lobes showing mass flow. Silty material has spread out over the valley floors and as streams are small in volume even in spring, there is an absence of downcutting, most of the material being trapped in the depressions.

The first pingo-like feature (1 in Figure 1) examined was a conical hill 60 feet high containing a crater with an ice-covered pool about 25 feet across. (Figure 4).

Figure 4. Pingo-like features showing crater, scarcity of spruce and surrounding level pasture. (NRC photo)

The cone adjoined a higher ridge and supported a few small spruce, long grasses and horsetail. The material was a fine grey silt, showing some stratification, but due to much slumping into the crater, any upwarping of the bedding could not be determined. The silt appeared to be free of fines or rock debris. Some remains of burned trees were found. The feature rises from the surrounding level pasture at an angle of between 30 degrees and 35 degrees. (Figure 5).

Figure 5. Pingo-like feature showing the abrupt break between the surrounding pasture and the conical mound. (NRC photo)

At the foot of the lowest bench of the mountain was a circular ice-covered pool about 40 feet across (2 in Figure 1). The outer edges of the ice were cracked and raised in saucer fashion. Mud was visible in this crack, apparently being lifted by the ice. The pool was fed by a small stream running along the edge of the bench and the pool drained to a pasture on the opposite side. Large willows protruding through the ice in the centre indicated the shallow depth of the pool. The feature seemed notable because of its circular shape and the raised perimeter. (Figure 6).

Figure 6. Small circular pond, possibly an incipient pingo.
(NRC photo)

The most striking of the features (Figure 7) and the most obvious on aerial photos was a circular crater about 85 feet in diameter contained by a low rim rising about 18 feet at its highest point and breached downslope (3 in Figure 1). Red algae coloured the ice and the outflow. Small spruce and low bushes stood on the rim. In the matrix of brownish-grey silt were numerous water-polished sandstone slabs up to one foot in length. This feature was isolated from the other hills and ridges and was

Figure 7. Circular crater with low raised rim, taken from the summit of nearby debris hill.
(NRC photo)

surrounded by outwash flats traversed by a shallow braided stream emanating from the foothills. There was a higher and rather level ridge adjoining its northern border, covered by scattered spruce and willow thickets. Under this vegetation was outwash silt with occasional stones and small sandstone boulders. No stratification was noted in the material forming the rim.

Some other knobby hills in this group were roughly conical in shape but lacked any evidence of crater formation. They were assumed to be formed of slide debris.

Several large lenses of ground ice were reported and photographed near the third pingo-like feature (Figure 3). They occur in a steep bank of one of the ridges

and are overhung with turf. They are well above the present level of outwash deposition.

Two possible origins of these features are suggested. The first is that they are of thermokarst formation and so similar to kettles or the many small lakes which characterize the Alaska coastal plain. If large masses of ice or snow were trapped beneath the slide debris, it is possible that as normal erosional forces acted upon the covering material, these ice masses eventually became exposed and melted, leaving depressions which now appear as craters. Although many kettles have roughly circular perimeters, few are as perfectly round as the last two features described. This theory implies a destructional origin and there would be no stratification of the associated materials. Such materials should also be heterogeneous in composition, being derived directly from the mountain side. Some large stones do occur in the third example where the feature has little elevation.

The second theory is that their formation is similar to that of pingos. This implies a gradual pushing up from the centre and in some cases the creation of a crater by rupture and subsequent sinkage in the centre. The sinkage is due to the melting of an ice plug after rupture similar to thermokarst formation; that such ice cores exist in some pingos has been verified by drilling. The fine materials should theoretically show some stratification, warped upwards towards the centre. The investigation was too hurried and the season perhaps a little too early to determine this, although some stratification was noted in the first case. It is suggested that the thick local deposit of fine silts derived from decomposed shales and the high water content should create conditions suitable and perhaps ideal for the formation of pingos according to the as yet meagre knowledge concerning their formation. The conical shape and craters conform to those of many pingos observed northeast of the delta.

Conditions elsewhere on the alluvial fans adjacent to the Richardson Range are not conducive to pingo formation, as there is no blockage of drainage as in the case of the Black Mountain debris slide area.

These features require further study before concluding definitely that they are similar to the pingos along the Arctic coast. Their resemblance to other pingos, however, suggests a similar process, and in so doing, suggests that pingo formation may not be peculiar to coastal areas. Rather, conditions necessary to their formation may be duplicated in other areas of quite different geomorphic origin.

PRECISIONS AU SUJET DU TERME RUISSELLEMENT EN HYDROLOGIE [1]

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Université Laval

RESUME

Le ruissellement (runoff) constitue l'un des moments essentiels du cycle de l'eau et se trouve à être l'une des trois vocations qui attendent les eaux tombées.

Les chercheurs en hydrologie se sont naturellement appliqués davantage à l'étude du phénomène qu'à celle du terme; celui-ci reste défini d'une façon imprécise et les expressions utilisées sont mal articulées aux concepts circonstanciés que la réalité complexe a fait naître.

Les comportements climatiques, les caractéristiques du bassin, le facteur temps, l'intervention humaine et la littérature hydrologique sont à la base de nos suggestions de vocabulaire touchant les qualificatifs à apporter au mot vague de ruissellement.

Ce dernier (R) pourrait être b ou v: n ou h; sur le plan de l'expression arithmétique, le R est un module Q, une "épaisseur" P' ou un volume V; suivant que l'on fait intervenir le bassin ou non, l'on a Q ou q, absolu ou spécifique. Le Rto peut se subdiviser en Rpr et Rre; plus précisément, le Rre peut être du Rni, du Rgl, Rpe; sous une autre optique, le Rto comprend du Rs, Rna, Ri. S'il n'y a pas de corrections, le Rto équivaut à du Rb plus ou moins de Rd et du Rgr. En fonction de la longueur de la période considérée, le R devient Rglo, Ra, Rsa, Rm, Rqu, Rh. Enfin, en hydrographie, le R est ex, en, ar ou st.

Ces abréviations de termes correspondent à des mots souvent nouveaux mais applicables à des phénomènes connus. Grâce à ce vocabulaire, nous espérons que les études hydrologiques vont gagner en précision, en clarté et en valeur représentative.

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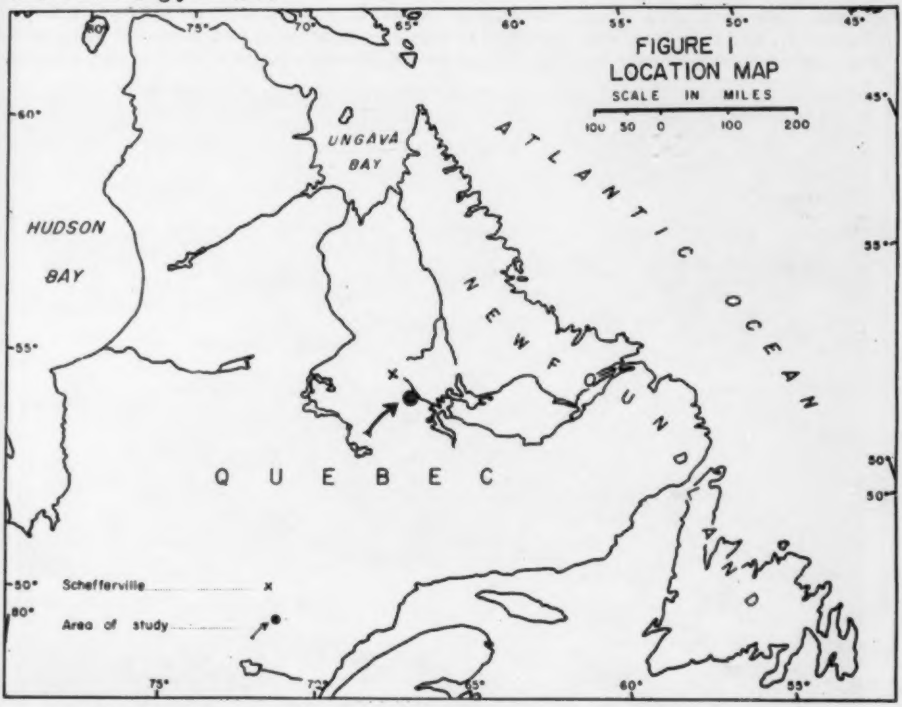
[1] Soumis à la sixième réunion annuelle de l'Association Canadienne des Géographes, Montréal, 1956.

TILL PATTERNS IN CENTRAL LABRADOR [1]

J.D. Ives

McGill University

The development of new techniques and the increasing volume of work on late Wisconsin events in North America have resulted in a rapid advancement of our knowledge of the deglacierization of this continent, and such knowledge provides an invaluable basis upon which to assess the process of events further back in time. It is significant, however, that most of our knowledge is confined to the marginal areas of the Wisconsin ice sheets, and that knowledge of the so-called "centres of dispersal" remains alarmingly limited.



Labrador-Ungava has been regarded by many workers as one such area of ice dispersal, and one of the areas in which ice remained longest in late Wisconsin times. This hypothesis has recently been brought into sharper focus by the advent of large scale physiographic reconnaissance by the use of aerial photographs. Indeed, the

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[1] Presented at the Sixth Annual Meeting of the Canadian Association of Geographers, Montreal, 1956.

present investigation was prompted by the mapping of Labrador-Ungava from the air by the McGill research group under the direction of Dr. F.K. Hare.[1]

The establishment of the regional patterns of the drumlins and eskers has been particularly valuable. The plotted distribution has prompted the re-affirmation of the hypothesis that the central area of Labrador-Ungava was a major centre of ice dispersal, at least towards the close of Wisconsin times. It must be admitted, however, that such an interpretation of the complicated, rather than the simple, distribution of the glacial features, is by no means the only one possible. It was the purpose of the present work, carried out from the McGill Sub-Arctic Research Station at Knob Lake, to ascertain, if possible, the strength of such a hypothesis by detailed small scale investigation in the field.

In addition to the regional pattern of glacial deposits, a small scale pattern, of what will be called "rippled till" is strikingly apparent on some of the aerial photographs. One such area of patterned till is located 45 miles southeast of Knob Lake (Figure 1), and this area was examined in detail in an attempt to assess the composition and morphology of the rippled till and its relationship to the drumlins and eskers

Figure 2. General view of the "rippled till" country from the ridge of bedrock looking towards the northeast. Note the series of peninsulas, or ripples, in far distance and esker in centre.

[1] Hare, F.K.: "Mapping of Physiography and Vegetation in Labrador-Ungava. A Review of Reconnaissance Methods", The Canadian Geographer, 5, 1955, pp. 17-28.

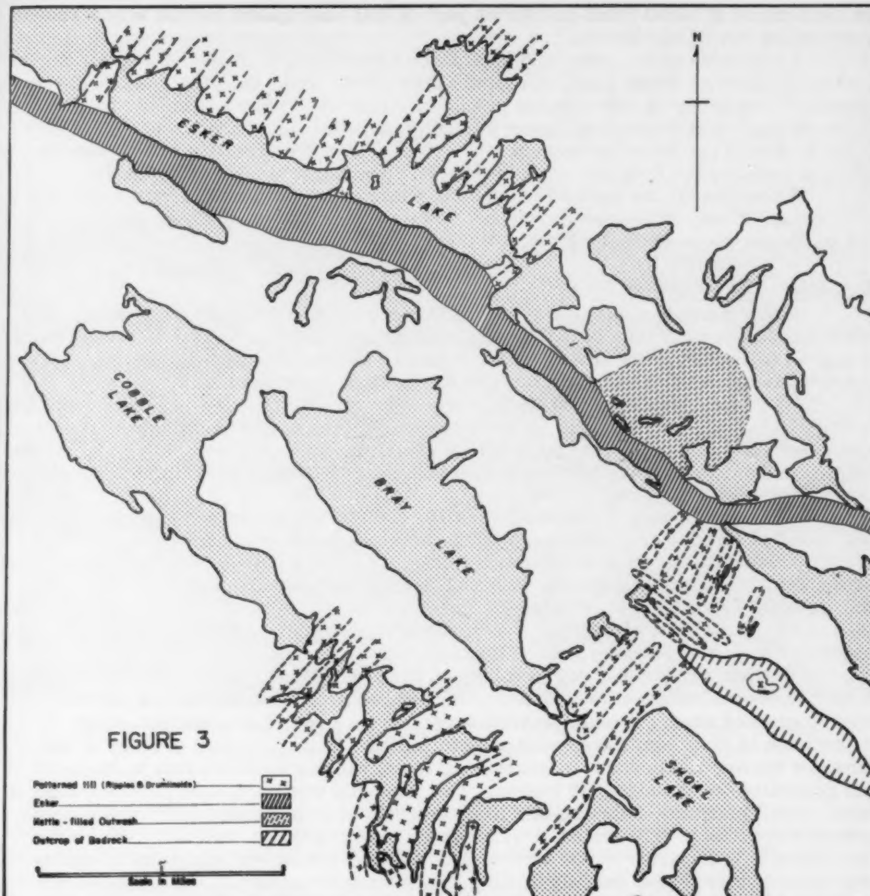

FIGURE 3

in the vicinity. To proceed from an examination of the small scale pattern to that of the overall regional pattern of the glacial deposits may assist an understanding of the final stages of the Wisconsin in that particular area.

The area examined lies to the east of Menihek Lake between Esker and Shoal lakes, and is drained by the upper waters of the Ashuanipi River. It lies within the area of the iron-bearing sedimentaries which has been called the "Labrador Trough" in which the structural trend runs northwest-southeast. The area may be described topographically as an undulating till plain with the local relief rarely exceeding 100 feet. The monotony of the plain is sharply broken, however, by a well developed esker - hence the name Esker Lake - which rises more than 150 feet above the surrounding country and follows a course sub-parallel to the regional drumlinoid trend. Occasional bedrock hills emerge above the apparently thick mantle of till to a height of more than 150 feet above the surrounding country. (Figure 2). The area is occupied

by a multitude of small lakes and forms part of that vast upland plateau which Tanner aptly called the "Lake Plateau".[1]

Over much of the area, and particularly northwest of Shoal Lake and along the northeast shore of Esker Lake, the gentle undulations of the till plain take on the remarkable regularity of sub-parallel ridges or "ripples" varying from 150 to 200 paces in width and displaying a general southwest to northeast alignment, perpendicular to that of the drumlins and eskers. The trend of the drumlins and eskers is taken to indicate the final direction of flow of Wisconsin ice. (See Figure 2).

From the air the pattern of land and water alone serves to bring out the rippled areas. Some of the best developed ripples form a series of 16 peninsulas along the northeast shore of Esker Lake.

The Esker Lake Ripples

Esker Lake is actually a series of three lakes and the narrows between each are localized by particularly well developed ripples. The ripples are best developed along the shore of the two northerly-most lakes, whereas the pattern becomes less distinct further south and finally merges into a weak drumlinoid trend.

The 16 peninsulas of Esker Lake are emphasized in the field by a prolongation of the dividing lake embayments in the form of bay-head marshes. Each ripple was examined and pits were dug at intervals of 10 paces perpendicular to the trend of the ripple, and supplementary pits were also dug along the ripple crests and in scattered places throughout the area.

The ripples vary in width between 150 and 200 paces and are separated by depressions of similar dimensions; in other words, the distance from crest to crest varies between one-sixth and one-quarter of a mile. The maximum relief of the crest above the floor of the embayment was measured as 50 feet, although in places this was as little as 20 feet; lengthwise the ripples remained distinct for up to half a mile. Except for small wave-cut cliffs, the contours were smoothly flowing and no abrupt breaks of slopes were observed. (Figure 4).

The numerous pits, dug to depths of up to 10 feet, but generally not exceeding four feet, revealed that the ripples were composed predominantly of medium to coarse grained sand. Pebbles were observed in very few places and no preferred orientation of their long axes could be determined. The upper part of many of the sections showed a thin cover of coarser material ranging up to six feet in diameter, but generally not exceeding 12 inches. This material was composed predominantly of local rock, quartzite, dolomite and ironstone, although occasional pieces of granite-gneiss were found. The material was angular to sub-angular, and striations were occasionally well preserved on blocks of dolomite. This cover was quite irregular, and in many places was entirely lacking. It is interpreted as ablation moraine and appears to bear no relation to the morphology of the rippled pattern.

The result of this digging has led to the conclusion that the entire area is composed of medium to coarse grained sand with a very small proportion of coarser material, most of which is confined to the surface. The inadequacy of the exposures revealed by digging, and the difficulty of discovering any coarse sorting by this method are recognized.

South Esker Lake

This area is interesting because here the ripples gradually merge into a weakly developed drumlinoid trend. No clear-cut contact was observed although the composition of the drumlinized ground was essentially similar to that further north.

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[1] Tanner, V.: Outlines of the Geography, Life and Customs of Newfoundland-Labrador, Helsingfors, 1944, pp.61-62, and Figure 18.

Figure 4. The Esker Lake Ripples. View towards the northeast across the crest of the esker. Bedrock hills on the horizon.

Southwards again the land rises and the drumlinoids in turn are masked by a complicated development of the esker - a large tract of kettle-filled sand which appears to have been deposited at a later date than the drumlinoids. However, this age differential is difficult to ascertain owing to the similarity of the constituent material of the two topographic forms.

Finally, in the Esker Lake area, a wave-cut cliff in the side of a ripple provided the only natural exposure which was discovered. When the slump material had been cleared away, a good vertical section 12 feet deep was exposed. The top three feet was in medium to coarse grained sand. This overlay, with a gently irregular contact, medium grained sand which continued to the base of the section. Five horizontal partings of coarse grained sand were observed in the lower part of the section, while throughout were scattered iron-stained concretions which were presumeably of a secondary nature.

This was the only instance where any sign of stratification was observed in the area.

Another important point about this particular ripple is that it merged directly into the esker, meeting it at right angles. As the esker was approached a gradual increase in the coarseness of the material was observed, particularly in the surface material. The esker, while composed predominantly of sand, contained a high proportion of material between gravel and cobble grain size.

Till Patterns Between Esker Lake and Shoal Lake

The area between Esker Lake and Shoal Lake displays a strongly developed pattern of rippled till, with much of the area between the ripples occupied by small lakes elongated southwest to northeast. This pattern extends along the southeast shore of Bray Lake, where, however, the relief becomes less marked and the inter-crest areas are largely marsh-filled. (Figure 5). As the thickness of the till diminishes,

Figure 5. View from the crest of one ripple looking towards the next. Here the intervening depression is partially filled with lake and marsh.

the whole pattern gradually fades out on the northwest shoulder of a ridge of bedrock. Along the northeast flank of this ridge three distinct drumlinoids occur with a maximum relief of 15 feet. Northwest of the drumlinoids there is an abrupt change in the alignment of the till with the northeast to southwest ripple trend again prodominating. The whole area between the drumlinoids and the esker, about a mile across, is characterized by a complex distribution of ridges and kettles with small elongated areas of marsh or lake between the ridges. At their southwestern extremity the ridges have the same appearance as the ripples already described, but towards the esker they become narrower and higher until they resemble small eskers. (Figure 6). Three such ridges were particularly well developed, and but for a small col beneath the flank of the esker, they gradually increased in height until they ran into the esker at right angles. As in the instance described above, the proportion of pebbles and gravel to sand increased as the esker was approached.

Figure 6. As the esker is approached the broad ridges become narrower and steeper and have the appearance of a small esker.

Scattered pits dug throughout the entire area revealed the same results as in the vicinity of Esker Lake - a non-sorted sand capped by an irregular cover of ablation moraine.

It would be interesting, in fact necessary, before any further progress could be made with this problem, to obtain knowledge of the till composition between the ripples. Exposures were unobtainable owing to the presence of lake water or a considerable depth of marsh. Until more evidence is available it will be assumed that the entire area is composed of a large proportion of medium to coarse grained sand.

Origin of the Rippled Till

Features which are superficially similar to those described above, and which may be generically related to them, have been found to occur in southern Scandinavia,[1] on the Canadian Plains, and in various other parts of the Canadian Shield.[2]

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[1] De Geer, G.: "Geochronologica Suecica Principles", K. Svenska Vetenskapasakad Handl, Ser.3, 18, 1940, pp. 125-130.

[2] Mawdsley, J.B.: "Washboard Moraines of the Opawica-Chibaugamau District". Trans. Roy. Soc. Can. Ser.3, 30, 1936, pp. 9-12.

Hypotheses put forward to explain such till patterns may be grouped under two headings. The first hypothesis can be related to Tanner who believed that such patterns were typical of "dead ice topography" and were caused by material being washed into crevasses in stagnant ice which were being widened and enlarged during progressive ablation.[1] This hypothesis encounters difficulties when the composition of the till, the strikingly regular form and the even spacing are considered. Also the ridges are as wide as the troughs, a characteristic which is difficult to relate to stagnant ice.

The regularity of the ripples has led other workers to associate them with annual recessional moraines.[2] In this connection mention must be made of a recent paper by Elson who describes what appears to be related features on the Canadian Plains and which he calls "washboard moraines". These he associates with an annual cycle of recession.[3]

The ripples in central Labrador-Ungava occur at intervals of one-sixth to one-quarter of a mile, which provides a reasonable order of magnitude for the annual recession of an ice lobe. However, given an annual ablation rate of as much as 30 feet, this would provide a surface slope of only two and one-half degrees for the ice lobe. Furthermore, when the significance of what is certainly "dead ice topography" and marginal drainage channels, found some tens of miles further north, is considered, it appears that down-wasting rather than marginal retreat was characteristic of the final stages of the deglacierization in this area. This would scarcely allow the formation of regularly spaced terminal moraines of considerable size. Indeed, as stated by Flint, the concept of marginal retreat has been somewhat overstressed; this seems particularly true when applied to the final stages of the Wisconsin.

From the evidence presented above it appears that neither hypothesis is completely satisfactory. The ripples, so closely associated with the esker, were probably formed contemporaneously with it. It is considered that much more field work will be required, and that deep drilling in particular might obtain more relevant information.

The Final Stages of the Wisconsin in Central Labrador-Ungava

Another method of approach is a general consideration of the glacial geomorphology of the entire Knob Lake area. Only a few references can be made to this here and a paper in preparation deals with this topic more fully. As mentioned above, the radiating pattern of the drumlins and eskers about the Knob Lake area has been taken to suggest that central Labrador-Ungava was one of the centres of glacial outflow.[4,5,6] Semi-permanent snowbanks in the area were examined and firn pits revealed a minimum of possibly three years' accumulation. This, together with the 25-inch isohyet,

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[1] Tanner, V.: op. cit., p. 209, and Figure 108.

[2] Syme, A. M.: Glacial Features in the Vicinity of Knob Lake, Labrador, Unpublished M. Sc. Thesis presented to McGill University, 1951, pp. 23-24.

[3] Elson, J. A.: "Periodicity of Deglaciation in North America. Part II, Late Wisconsin Recession", Geog. Annaler, 2, 1953, pp. 95-104.

[4] Low, A. P.: Geological Survey of Canada, Ann. Rep., VIII, Ottawa, 1896, pp. 1L-387L.

[5] Odell, N. E.: "The Geology and Physiography of Northernmost Labrador", In Northernmost Labrador Mapped from the Air, by A. Forbes, New York, American Geographical Society, 1938, p. 206.

[6] Tanner, V.: op. cit., pp. 174-177.

which encircles the area, may be used as further evidence to suggest that even today the area approximates a condition of glaciation, and therefore it seems reasonable to assume that some of the final remnants of the Wisconsin ice were situated in this area. This is borne out by the field evidence which includes marginal drainage channels, overflow channels and glacial lake shorelines. To assume from this evidence that the Knob Lake area was the centre of ice dispersal is fallaceous and is based upon the dangerous assumption that conditions towards the close of Wisconsin times were relatively similar to those prevailing at an earlier period.

Field evidence, in the form of glacial striations, chatter marks, roches moutonnées, and erratic blocks, indicate that the last regional movement of ice, at least within a 50-mile radius of Knob Lake, was from the northwest or north-northwest towards the south. No evidence of local movement later than this was observed strengthening the hypothesis that the final disintegration was characterized by stagnation and down-wasting. However, two older sets of striations were discovered, one bearing north-northeast to south-southwest and the other east to west, and emphasize the complexities of the problem and the widely changing conditions during the last glacial period.

The present state of our knowledge allows no definite interpretation of either the rippled till, the small scale pattern, or the drumlin and esker trends, the large scale pattern. However, the purpose of this work will have been achieved if it has brought into open discussion the problem of the interpretation of the till patterns, and if it has emphasized the need for detailed field studies nearer the possible centres of glaciation.

ESSAI DE CLASSIFICATION DES RAPIDES DES RIVIERES DU NORD-OUEST QUEBECOIS

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RESUME

Toute rupture de pente plus ou moins brusque de la surface d'un cours d'eau se traduit des eaux vives à la cataracte en passant par le cassé, les rapides et les chutes. Les eaux vives et surtout les rapides sont une des caractéristiques des rivières du nord-ouest québécois, même de tout le bouclier canadien. Ces rapides sont dûs à un déblaiement incomplet du drift des glaciers pléistocènes de la part des cours d'eau, ou complet mais où un seuil de roche en place est venu former barrage, manifestations premières de l'érosion verticale.

Rapide à l'aval, suivi d'un cassé, à l'entrée de la rivière Opawika dans le lac Doda (Cliché C.L., no. 3287-55-H, Off. prov. de Publ., Serv. de Ciné-Phot., Qué.).

GLACIAL FEATURES OF THE HEARST-COCHRANE MAP-SHEET AREA

- An Aerial Photograph Reconnaissance -

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Introduction

The original map upon which this paper is based was the result of an intensive study of the aerial photographs of a large portion of Northern Ontario during the summer of 1955. This study made under the auspices of the Geographical Branch, is a continuation into Ontario of the recently completed work of a group in the Geography Department of McGill University who were engaged in an investigation of the surface characteristics of Labrador-Ungava by means of aerial photography.[1] The area similarly investigated in Ontario is that covered by the Albany River 1:1,000,000 World Aeronautical Chart (No. 2220).

The method employed in the study was almost exactly the same as that described by Hare, that is, the direct sketching of observed physiographic detail from the vertical photographs onto the standard black and blue 8 miles to 1 inch base maps of the Canadian "National Topographic Series".[2] In the case of this Northern Ontario study, however, more detail was mapped. Being a considerably smaller area than Labrador-Ungava it was possible to spend more time studying individual photographs. Besides, in the main, the photographs available for the Albany River area were probably somewhat superior to those available for the Labrador study at the time it was carried out. Practically all of the Ontario area was flown at 30,000 or 35,000 feet between 1951 and 1954, mainly by Spartan Airways. These two factors particularly made it possible to use a more detailed landform classification than that utilized in the Labrador-Ungava study.

The present paper is an interim report on the information plotted on one of the four 8 miles to 1 inch base maps (1:560,000 approx.) required to cover the Albany River 1:100,000 map sheet area. The map selected for this was the Hearst-Cochrane sheet (National Topographic Series Sheet 42 SE), mainly because it presents the most complex, and thus the most interesting problems. Analyses of the other sheets will be presented in a later report.

For the purposes of this paper, the glacial features mapped in the original interpretation have been divided into two classes:

1. Glaciation - features attributable to glacial advance, i.e.: drumlinoids, drumlins, and other distinguishable manifestations of the erosional or depositional action of a moving ice sheet.

2. Deglaciation - features associated with the recession of ice sheets, i.e.: stadial moraine, outwash plains, eskers, kames, and beaches where distinguishable on the photographs.

A brief description of each of these classes and a preliminary discussion of their significance are presented here to form a basis up on which more detailed analysis and critical comment can be made.

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[1] Hare, F.K.: Mapping of Physiography and Vegetation in Labrador-Ungava. The Canadian Geographer, No.5, 1955, pp.17-28.

[2] Ibid., p.19.

Drumlinoids and Related Features

During the interpretation of the aerial photographs all patterns showing the marked parallelism characteristic of drumlins or drumlinoids were mapped with a specific symbol. These symbols were oriented on the map in the same direction as they are oriented on the ground. In addition linear patterns which also showed a marked parallelism, but could not be positively identified as drumlins or drumlinoids were mapped with a separate symbol as "glacial directions", i.e.: indicators of the direction of glacial movement. Care was taken to distinguish such patterns from linear features caused by fault-lines or other bedrock phenomena. In most cases, although sometimes very faint, the glacial directions were so closely related either in appearance or in orientation, or both, to the drumlinoids that it was felt safe to assume that they were in fact manifestations of the direction of glacial movement. Some groups of these glacial directions appeared to be drumlin fields buried under later depositions of some other origin, being visible on the photographs now only as "flow patterns". Other directional features were a little more definite, such as two very straight sides of a shallow lake or pond oriented in exactly the same direction as nearby drumlinoids. In some cases, glacial directions were crag and tail phenomena, found, of course, almost entirely in the areas of a large percentage of bedrock outcrop.

Figure 1 shows the mapped pattern of orientation of all of those features of glacial deposition and/or erosion, the drumlins, drumlinoids and glacial directions which unquestionably are related to glacial movement or advance. The mapped pattern of these is obviously complex, and it certainly indicates that there was more than one major regional movement of an ice sheet over the area. In fact several advances or readvances seem to be indicated by the pattern. Broadly speaking there are three major directions of orientation. These include approximate directions of northeast to southwest, northwest to southeast, and almost north to south or a few degrees west of north-south. This is, of course, assuming that the direction of movement was from a northerly to a southerly direction, and there is certainly no reason to believe that it was not.

The distribution of the drumlinoids and glacial directions in this area is also indicated on the map. Where there are no such features mapped they do not appear on the aerial photographs. From this distribution it would appear that there are four major groups, or series of these features. Starting in the northeast corner and moving anti-clockwise around the area, one major series of drumlinoids lies largely to the north of the C.N.R. "Northern" line and extends from the eastern border of the map sheet (taken here as 80° W. longitude) to approximately the east bank of the Abitibi River. This series is made up largely of well developed drumlinoids, but it does include some drumlins which are prominent in the area southeast of Two Peak Lake lying directly east of Little Abitibi Lake, in addition to some weaker "flow patterns" located south of Little Abitibi Lake. Most of the drumlins seem to be associated with an extensive morainic deposit to the south of them. The well developed drumlinoids of this series, as far as one can judge from the aerial photographs, have neither been disturbed nor overlain by glacial, lacustrine or glacio-fluvial deposits since the time of their formation. Some of the most northeasterly of these might be cited as "classical" examples of the long furrows, "ispatinows", or drumlinoids so widespread in the northern glaciated regions of Canada. In this particular area they control the drainage, which here exhibits a pronounced trellis pattern.

The second major series of drumlinoidal features also lies largely to the north of the C.N.R. "Northern" line and extends from some 10 miles or so west of the Abitibi River to the western border of the map-sheet. The predominant direction of orientation here is north northeast to south southwest. However, some interesting variations from the main direction of orientation do occur between the Mattagami and Kapuskasing rivers. This particular field is remarkable for its curved drumlinoidal patterns. Towards the north of the map-sheet near the "big bends" of both the

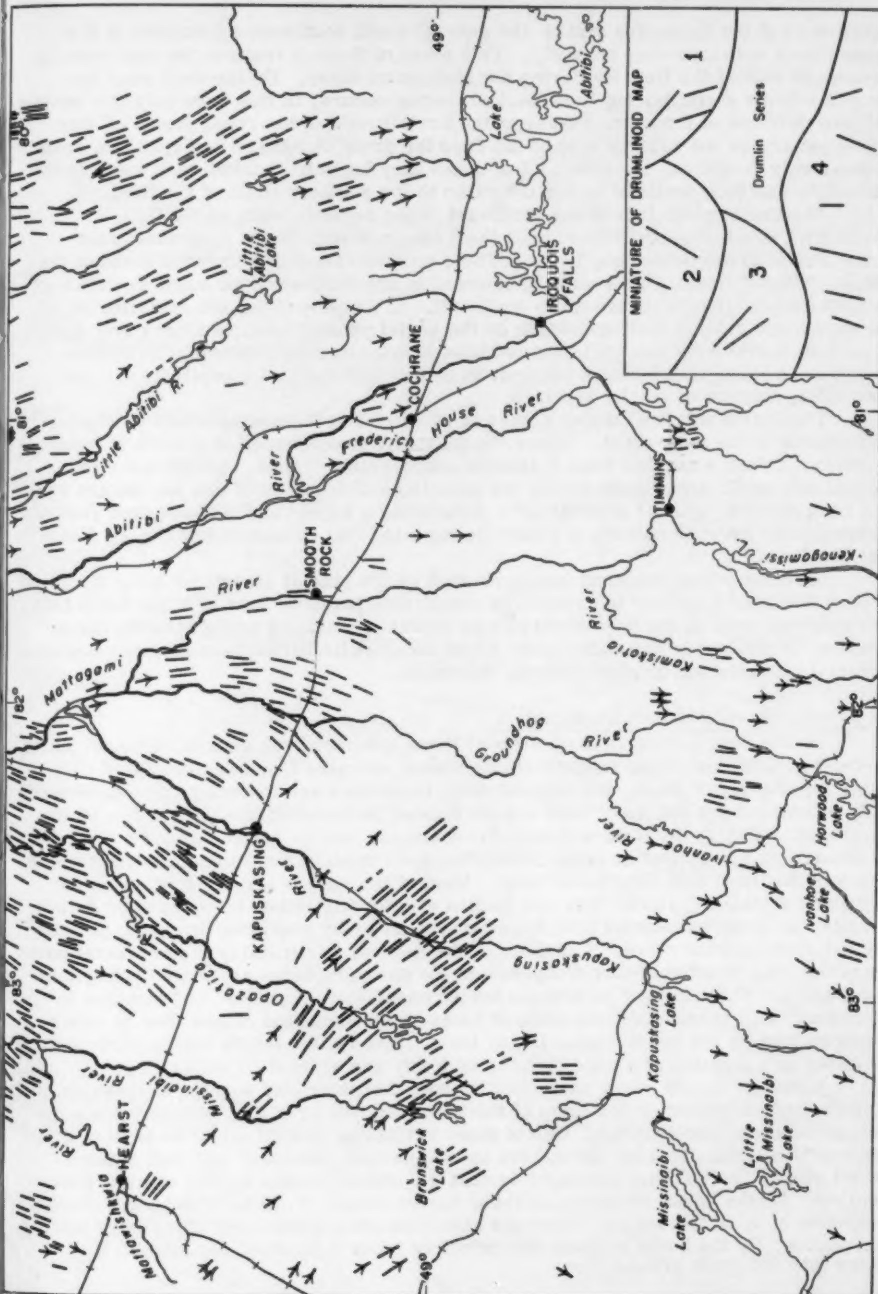

FIGURE 1:—DRUMLINOIDS AND GLACIAL DIRECTIONS

Mattagami and the Opazatika rivers the general south southwest orientation of the series flares outwards very abruptly. This outward flare is towards the southeast on the eastern side of the field bordering the Mattagami River. On the west near the Opazatika River a similar but less marked flaring occurs, in this case only the more southern portions of the axes of some of the drumlinoids are curved. South of this flaring pattern on the eastern side of the field the drumlinoids are deployed in a south southeasterly direction, but within a few miles they begin to recurve back towards the southwest, and then continue in this direction to the southern limit of the field.

The third series lies to the southwest of the second, south of the C.N.R. "Northern" line and extends from near the western border of the map-sheet eastwards almost to the Groundhog River. Their southern limit is somewhat north of the C.N.R. "Main" line. This series is oriented in approximately the same direction as the first series, that is northwest to southeast. In some sections the drumlinoids of this series are clearly distinguishable on the aerial photographs, in others they are not as well marked but are still recognizable as drumlinoidal features. Numerous linears and rectangular bedrock patterns in this area somewhat complicate the air photo interpretation of glacial features.

The fourth and final major series is that found in the southern and southwestern portions of the map-sheet. These, in the main, are oriented in a north to south direction although a number have a definite southwesterly trend. Except for a few isolated and small drumlinoid fields, the drumlinoidal features of this series are what have been termed "glacial directions". This being a higher and more rugged area of predominantly bedrock outcrop it cannot be expected that extensive drumlinoid fields would be found.

Save for a few scattered instances such as the glacial directions lying directly north of Kirkland Lake and the very faint drumlinoid patterns west of Night Hawk Lake, the remaining area of the map-sheet has no visible drumlinoid or "glacial direction" patterns. Presumably any such features that do exist lie buried beneath later deposits of glacial, lacustrine, or glacio-fluvial materials.

Landforms Associated with Deglaciation

On the Hearst-Cochrane map-sheet there are numerous eskers, outwash plains, ice-front kames, and other recessional or stadial moraine features associated with an ebbing ice sheet. Of these, the most striking landforms are the many eskers. Especially prominent are the long, wide eskers located in the northeastern portion of the map-sheet. (Figure 2). One of these, for example, can be traced for over 100 miles, and the others are almost as long. However, their most remarkable characteristic is their variability of both length and form. Most of the eskers are not continuous for very great distances, rather they are broken at intervals either by outwash or deltaic deposits, no doubt associated with the esker itself, or by overlying deposits, presumably till or lacustrine clays. A number of the eskers, particularly in the central portion of the map-sheet suddenly disappear on the photographs as an easily distinguishable feature. These appear to become buried under later deposits, and in some instances are still traceable along lines of lakes or disconnected ridges, but in other instances they do not appear again in any form. The visible length varies from about 100 miles to a fraction of a mile, but the majority are at least 20 miles long.

Although almost every esker has its own characteristic surface expression, two principal variations in the form of the eskers in this area are distinctly discernable on the aerial photographs. One of these variations is what might be termed a "normal" pattern. That is, the eskers show a narrow, sinuous, and well defined central ridge. In the other principle variant the central ridges appear to have been modified. On the aerial photographs these have a broad, flat aspect and often reach a total width of up to two miles. They are also frequently associated with wide, flanking sand plains. On the basis of these two principle types it is possible to divide the eskers into two main groups.

FIGURE 2: — ESKERS, OUTWASH, AND OTHER SAND DEPOSITS

Well defined esker ridge
Poorly defined esker ridge
Deltaic deposits
Beaches, ice contact faces
Longitudinal dunes or beaches
Upsiloidal dunes
Well defined sand and/or gravel
Poorly defined sand and/or gravel

10 0 10 20

One group lies mainly to the south and southwest of the C.N.R. "Main" line; the other to the north and northeast of this railway. The first group is made up largely of eskers with well defined central ridges, the second appear to have been modified, or reworked in some way. In addition those of the second group disappear and reappear at intervals, and generally are associated with more extensive outwash and deltaic deposits than the first group. One further important difference is the fact that the eskers of the first, or southerly, group are oriented in approximately the same direction as the drumlinoids and glacial directions, whereas those of the second group, except in two or three cases, definitely are not. The distribution and comparative size of the eskers is also significant. The southwesterly group are smaller, shorter but more dense in their distribution than those of the north. Judging from remnants that emerge through the surface deposits here and there in the north, however, it may well be that there are just as many as in the south, but more of them are deeply buried. Nonetheless, there is a distinct difference in density between the two groups.

Sand plains and outwash plains are also prominent on this map sheet. Here again, there seems to be two major groups or belts. One extends in a direction a little north of west from the southeast corner of the map and is more or less continuous, but includes a number of interspersed flat clay plains. The other trends in a more or less east-west direction but is broken or discontinuous. The outwash plains of both belts frequently have an esker backbone. No doubt of considerable significance also is the fact that the southern belt has numerous "secondary" features associated with it, whereas such features are comparatively rare in the northern belt. These secondary features include almost straight or gently curved lines, possibly representing beaches, the positive identification of which from the photographs is difficult. Other so-called "secondary" features are the numerous deltas which appear in this great sand belt. These, since they are fairly closely related along latitudinal lines, no doubt represent temporary, perhaps annual, halting places of an ice sheet during its recession. They also indicate that the esker streams were debouching into a body of water. Not all of the esker-deltas are found in the "sand belts". Two of the most outstanding series are associated with the two easternmost large eskers. Each of these has a well formed series of five deltas certainly indicating that as the ice front receeded the pro-glacial lake lying in against it migrated northwards with the ice front.

To the south and southwest of Hearst is a large moraine-like deposit which continues westward into the area of the adjoining map-sheet. Part of this deposit can be interpreted as outwash, but it seems more likely that it is a complex moraine feature as, in places, it has very pronounced ice-contact faces. This feature could be a continuation of the Cochrane moraine, although it seems more likely that it is an interlobate moraine, for on its western side the drumlinoids are oriented in a northeast-southwest direction whereas on its eastern side they are oriented in northwest-southeast direction. Finally, one other important group of depositional landforms discernable on the aerial photographs consists of the isolated hills of obviously sandy or gravelly material which are interpreted as ice-front kame deposits. The most prominent of these occur near the centre of the map between the Mattagami and Groundhog rivers. Others, according to interpretation, occur northeast of Fredrick House Lake.

Although perhaps not directly associated with deglaciation, two additional landform features are worthy of brief mention. These are the numerous sand dunes and a, thus far, nameless circular feature that is widely distributed throughout this map area. The sand dunes are found on practically all of the major outwash plains, particularly these in the southern belt. These plains subsequent to deposit have obviously been subjected to strong wind action which has apparently extended the plains over broad areas and built up dune formations in the process. The dunes take two forms, longitudinal or transverse dunes, and barchans. The latter are readily identifiable on the aerial photographs, but the former are difficult to interpret as one cannot always be certain

as to whether the linear sand patterns are actually dunes rather than beaches or ice-contact faces. Positive identification of these features will have to await interpretation from lower altitude aerial photographs or field work.

The most noteworthy aspect of the barchans is their disposition. With one minor exception, the convex sides of the barchans are all oriented in an easterly direction. This certainly proves that the prevailing winds at the time of the formation of the dunes were from the east rather than the west as they are today. This prevailing wind direction may also help to explain the apparently most recent ice advance of late-Wisconsin times which was from a northwesterly direction in part at least.

The circular patterns which frequently appear on the aerial photographs, often in groups and often overlapping, are unnamed and practically unknown as far as the writer is aware. For the lack of a better name and because of the fact that nothing appears to be known about them they will be referred to here simply as "natural circles". They appear on the high altitude photographs as fine white or light grey rings. They resemble at first glance water or chemical stains on the photographic prints, however, it has been definitely established that they do exist as a natural phenomena. Appearing as they do in coniferous stands, one might wonder if they are of a vegetative origin, but this does not seem to be the case as they are discernable in logged over areas which, along with other evidence, suggests a physiographic feature.

The observed natural circles vary in diameter from about 200 yards to over one mile. Under the stereoscope it is very difficult to decide whether they are slight elevations or slight depressions in the ground, if either. The only certain fact is that they are outlined by a narrow, remarkably circular, treeless border, presumably largely sphagnum moss and other low types of vegetative growth. Personal knowledge in conjunction with the air photo interpretation indicates that they are found in areas underlain by either sandy silt or silt-till. They do not appear to be found in areas of either sand or clay. The writer surmises that these curious "natural circles" are periglacial phenomena, perhaps some thermokarst feature.

Discussion

The foregoing brief description of the more important glacial landforms of the Hearst-Cochrane map-sheet as interpreted from aerial photographs introduces a number of perplexing problems regarding the glaciation of the area. Obviously such problems cannot be completely solved by an aerial photograph reconnaissance of this nature,but some of the outstanding problems can be discussed and some suggestions concerning the possible glacial events of this area put foreward as a working hypothesis.

The most outstanding fact on this map sheet, as a glance at Figure 1 will show, is that there have been at least two comparatively recent glaciations. Although one cannot be entirely certain from aerial photographs, it is more than probable from the record of the orientation of the drumlinoids in this and the surrounding areas that the earlier glaciation spread from Labrador-Ungava in a southwesterly and southerly direction. As a part of the Northern Ontario project, drumlinoid distribution and orientation was plotted for the whole of Ontario and adjacent portions of Quebec north of 48° N. latitude. From the map of these it seems obvious that the latest major glaciation of the whole region was generally from a northeasterly direction, but had started to turn southwards along a line joining the southern end of Lake Mistassini in Quebec and the northeasternmost shore of Lake Superior. It seems reasonable to correlate this major ice advance with the late-Wisconsin Mankato glacial advance, although there is not direct evidence for such a correlation other than the assumption that pre-Mankato drumlinoids or similar forms would be destroyed by the Mankato advance. On the Hearst-Cochrane sheet this advance is probably represented by the drumlinoids of series 4.

The melting of the Mankato (?) ice sheet probably created a large pro-glacial lake which migrated northwards from the contemporary height of land with the receeding ice-front constituting its northern shore. The lake no doubt eventually covered a large portion of Northwestern Quebec and Northern Ontario including much of the area of the Hearst-Cochrane map-sheet. It is assumed that the southwesterly group of eskers on Figure 2 were, in the main, beyond the southern borders of this lake. Although the small esker-deltas associated with some of them certainly indicated that the eskers were debouching into water. Such bodies of water may have been small, local lakes, or may well have been bodies of water lying in the deep pre-glacial north-south valleys which formed southerly embayments of the pro-glacial lake. Whatever the case, the eskers of this section were apparently little modified by lacustrine activities and certainly not overriden by a later glacial advance. The remaining eskers of the map-sheet on the other hand were apparently considerably modified in places, completely buried by later deposition.

It is postulated that recession of the Mankato (?) ice sheet continued northwards to some position beyond the present southern end of James Bay, perhaps to the latitude of Akimiski Island. During this retreat it is inferred that at least some of the large eskers were formed, especially those in the central sections where there are presently a number of esker remnants visible on the aerial photographs. The existence of this lake in front of the Mankato (?) ice sheet is, of course, conjectural. There is no direct evidence of such a lake that can be interpreted from the aerial photographs. However, two sets of varved clays with a layer of boulder-free "boulder clay" between them have been found in the Northeast Bay of Night Hawk Lake.[1] The significance of this cannot be completely evaluated at the moment, but it strongly suggests the possibility, even probability of a pre-Ojibway pro-glacial lake in this area.

It is further inferred that when the Mankato (?) recession had reached well into the present James Bay area, a marine invasion took place. This seems to have extended southwards to elevations that are now approximately 800 feet above the sea. Deposits of blue-grey clays thought to be of marine origin are reported from the Kapuskasing area.[2] Marine clays buried by till have also been discussed by A.P. Coleman in a report by Dyer and Crozier,[3] and similarly buried marine clays have been observed by the writer on the Albany River. Admittedly such evidence is not conclusive and the correlation may be wrong as there is also evidence of a pre-Mankato marine inundation, but the information is recorded for what it is worth.

Following the Mankato (?) recession there was another ice advance, this time from the Northwest (Tyrrell's "Patrician centre" ?). On the map sheet this is shown by the drumlinoid series No.3. This series is undoubtedly of later origin than the southwesterly set since it not only cuts across these drumlinoids but also a number of eskers which are probably attributable to the retreating Mankato (?) ice.

The question of how far this second glaciation extended cannot be answered from the aerial photograph survey. However, a number of reports of the Ontario Department of Mines,[4] inform us of two distinct sets of glacial striae in various parts of the southeastern sections, such as near Kirkland Lake. One set varies from a few degrees west of South to ten degrees east of South, and the second set, cutting across the first, varies from twenty degrees east of South to forty degrees east of South. This

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[1] Laird, H.C.: "German-Currie Area, District of Cochrane", Report of the Ontario Dept. of Mines, 40, pt.3, 1931, p.16.

[2] Beare, George: Woodlands Division, Spruce Falls Power and Paper Co. Kapuskasing - personal communication.

[3] Dyer, W.S. and A.R. Crozier: "Lignite and Refractory Clay Deposits of the Onakawana Lignite Field", Report of Ontario Dept. of Mines, 42, pt.3, 1933, p.55.

[4] For example: Laird, op. cit., p.18.

clearly indicates that the glaciation from the northwest extended completely across most of the area of this map sheet. There is, however, no evidence that it covered the southernmost area where the north-south drumlinoids and glacial directions are indicated on Figure 1 (i.e., series 4). The northernmost extension of this ice movement is also unknown for the present.

One of the major problems of this map sheet is the correlation, or possible correlation, of the two sets of southeasterly-oriented drumlinoids (series 3 and series 1). It is possible that the two sets of drumlinoids do correlate, but if they do the explanation of the long eskers between the Abitibi River and the eastern border of the map sheet becomes most difficult. From the aerial photographs it is obvious that these eskers are modified. Moreover, these eskers are reported as being covered by a sheet of boulder clay which undoubtedly proves a glaciation subsequent to their deposition.[1] But, as previously described, the southern portions of these eskers, west of Lake Abitibi, have associated with them a series of small and apparently unmodified esker deltas that most assuredly would have been destroyed had they been glaciated. In addition, if these eskers were related to the first glaciation from the northeast, they and their deltas would surely have been destroyed by the second glacial advance from the northwest. The writer, therefore, attributes these eskers to the recession of the second (northwestern) glacial advance. If such is the case, the drumlinoids on the till which overlies these eskers must be the result of a third and final glacial advance. One small group of the drumlinoids and glacial directions of this northeastern series, however, may be related to the second glacial advance. The group of weak drumlinoids and glacial directions lying between Little Abitibi Lake and Lake Abitibi not only have a slightly different orientation, but also are probably more modified than the main group of drumlinoids to the northeast of them. Because of this, and the morainic deposit extending eastwards from Little Abitibi Lake, and the features interpreted as outwash plains extending westwards from the area of the same lake, it is thought probable that these two distinct sets of drumlinoids are unrelated.

The recession of the second glacial advance must have been the source for the long eskers of the Abitibi River area. It is apparent that during this recession there was a pro-glacial lake, probably Coleman's Lake Ojibway, ponded in front of the receding ice. Into this lake these eskers built the esker-deltas so clearly visible west of Lake Abitibi, as well as some of the outwash deposits to the south. When this glacial recession had reached as far north as the basin of the Moose River at least, Lake Ojibway was drained and a glacial readvance took place, as is shown by the drumlinoid pattern of series 1 and 2, and the till-buried eskers. This advance is no doubt the "Cochrane readvance" cited by Antevs[2] and the " Cochrane substage" postulated by Bryan.[3] The drumlinoid pattern shows that the advance took an asymmetrical lobate form, fanning outwards in southwesterly, southerly, and southeasterly directions from near the centre of the Moose River Basin. One flank of the lobe expanded southeastwards into Quebec and probably terminated along the moraine reported by Shaw in the middle of Harricanaw, Nottaway, and Broadback river basins.[4] This moraine

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[1] Satterley, J.: "Geology of Garrison Township, Dist. of Cochrane", Report of the Ontario Dept. of Mines, 58, pt. 4, 1949, p. 12.

[2] Antevs, E.: The Last Glaciation, with special reference to the ice retreat in northeastern North America; Am. Geog. Soc., New York, 1928, p. 104.

[3] Bryan, K.: "Correlation of the deposits of Sandia Cave, New Mexico ...., glacial chronology", Smithsonian Misc. Coll., 99, 1941, p. 57.

[4] Shaw, G.: "Moraines of Late-Pleistocene Ice Fronts near James Bay, Quebec", Trans. Roy. Soc. Can., Ser. 3, 38, Sec. 4, 1944, p. 79.

continues into the hummocky and sandy area south of Little Abitibi Lake where it becomes lost as far as aerial photograph interpretation on the scale of this study is concerned. In the central part of the Hearst-Cochrane area, a lobe of the Cochrane advance must have extended at least as far south as a line extending from Iroquois Falls almost as far west as the Kapuskasing River. Along this line, particularly at Nellie Lake and in the section between the Mattagami and Groundhog rivers, there is a series of kame deposits probably related to the Cochrane advance. Had they been laid down by one of the earlier advances they no doubt would have been destroyed, or at least more completely modified than they appear to be, by subsequent glacial or lacustrine action. It is apparent that there was no lacustrine activity associated with the recession of the Cochrane advance and that these kames were deposited at the front of this ice sheet.

Till deposits of the Cochrane advance, along with the Ojibway lacustrine deposits, covered most of the drumlinoids of the northwestern glaciation in this central section. Antevs inferred that it reached as far south as Iroquois Falls, but in the western sections the Cochrane advance apparently only extended southwards to approximately the C.N.R. "Northern" line and a few miles beyond, perhaps halting in part along the line of hilly morainic deposits between Halleborg and Hearst. This final glacial advance left a sheet of silty boulder clay over the area it covered, as is mentioned by Antevs and others. Most of this till sheet would appear to be thin. Observations by the writer along the Trans-Canada Highway between Cochrane and Hearst have indicated a maximum depth of three feet, often less, for this till sheet, which can be seen in many places along the highway overlying silty varved clay which is considerably contorted along the contact with the overlying till.

With regard to the chronology of the sequence of events postulated above, little can be said until more detailed work is completed. Flint, on the basis of a peat sample (Y-222) from Dugwal in Northern Ontario infers that this place was last deglaciated more than 6,730 years ago.[1] This date would seem to indicate a post-Lake Ojibway deposit in that locality which, according to the evidence on the aerial photographs as well as that of Antevs, is outside of the southern limit of the Cochrane readvance, and therefore does not give any indication of the date of the readvance. It does, however, suggest that Lake Ojibway was associated with the second glacial advance postulated above, and that there was little if any lacustrine development with the recession of the Cochrane advance.

Summary

A number of glacial landform features which are interpretable from aerial photographs are described for the area covered by the Hearst-Cochrane 8 miles to 1 inch map sheet. These include both the drumlinoidal patterns created by moving ice sheets, and various glacio-fluvial and outwash landforms associated with the recession of continental glaciers.

In the subsequent discussion of the distribution and nature of these landforms a sequence of late-Wisconsin events is postulated as a working hypothesis.

The hypothetical series of events worked out mainly on the basis of the evidence provided by the aerial photograph interpretation, may be briefly enumerated as follows:-

1. A late-Wisconsin glacial advance from the northeast - the Labradorean glacier - presumed to be correlated to the Mankato ice advance.

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[1] Flint, R.F.: "New Radiocarbon Dates and Late-Pleistocene Stratigraphy"; Amer. Jour. Sci., 254, 1956, p.279.

2. Recession of the Mankato (?) ice-sheet, along with the formation of a proglacial lake and a possible marine invasion.

3. A second glacial advance from the northwest covering all but the southern sections of the map-area and the complete or partial destruction of many of the eskers and other landforms of the Mankato (?) advance.

4. Recession of the second glacier and the creation of Lake Ojibway as well as the large eskers, with their associated esker deltas, of the northeastern area of the map. Continued recession of this ice sheet no doubt allowed the complete drainage of Lake Ojibway and possibly the beginnings of marine inundation in the James Bay area.

5. A readvance took place (Antevs' - Cochrane readvance) from the region to the north of the area of the Hearst-Cochrane map-sheet. This readvance took a asymmetric lobate form, and in part moved southward as far as approximately the latitude of Iroquois Falls where it formed kame deposits. This readvance also left a thin mantle of silty till covering the glacio-fluvial and lacustrine deposits associated with the recession of the second (northwestern) glaciation.

STREAM PIRACY IN THE CENTRAL PLATEAU OF HISPANIOLA

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McMaster University

Among the processes of geomorphology there are few which are of greater interest to geographers than stream piracy. Not only is it more widespread in its occurrence than many other types of surface modification, for it is not confined within narrow limits of latitude, altitude or relief, but it frequently has a profound effect on man's use of the land. The present paper deals with the incidence and the effects of river capture in central Hispaniola, more specifically in the area known in Haiti as the "Plateau Central".

In this island physical conditions greatly favour the development of drainage diversions. Much of the land is mountainous, with ridges and narrow valleys formed in rocks of varying degrees of hardness, and here there have been many small migrations of water partings as the headwaters of opposing streams have cut into one another's valleys. River captures in the mountains, however, will not concern us here, since they produce little change in the over-all character of the terrain.

Other diversions have a more far-reaching effect. There are in Hispaniola a number of elongated depressions, trending generally southeast-northwest, formed as a result of downfolding, or eroded in belts of relatively soft rock. These vales exercise a dominant control over the drainage pattern, but since they lie at different elevations, stream capture may occur between one vale and another. When this takes place there is a major disolocation of drainage divides coupled with a marked change in the character and the gradational activity of the streams concerned, and a consequent modification of landforms.

Since the Plateau Central is not only the most extensive, but also one of the highest belts of low relief, modifications in its drainage have been on a larger scale and of greater geographical significance than those occurring elsewhere in the island. As may be seen in Figure 1, whereas most of central Hispaniola once drained into the Caribbean Sea, the greater part is now drained into the Gulf of Gonave, while a small but expanding area drains into the Atlantic.

Turning now to a more careful examination of the Plateau Central (Figure 2), we find that it coincides almost exactly with an area of Miocene conglomerate which has been preserved within a broad synclinorium lying between anticlines of Eocene and Oligocene limestone. In fact the coincidence between the plateau and the Miocene formations is even closer than is indicated, for conglomerate underlies most quaternary deposits of the plateau as well as much of the area in the north mapped as limestone plain, this being largely the result of redeposition from solution in Pleistocene or recent times.

The original drainage of the plateau was southeastward, via the Tabara River, as is attested by the alignment of the course of that stream with drainage within the plateau, and also by the large alluvial plain which has been built up at the mouth of the Tabara. At this time, however, drainage on the plateau was slow and a mature erosional surface developed. The tilted beds of conglomerate were levelled off and covered in large part or entirely with a veneer of alluvium.

The first river capture occurred when the Rio Yaque del Sur cut through from the south to divert drainage of the basin into the long depression which separates the southern peninsula of Hispaniola from the remainder of the island, and which was at that time occupied by an arm of the sea. The main consequence of this diversion was rapid alluviation in the depression, causing it eventually to be filled in completely at its eastern end. This isolated from the sea a body of water in the centre of the de-

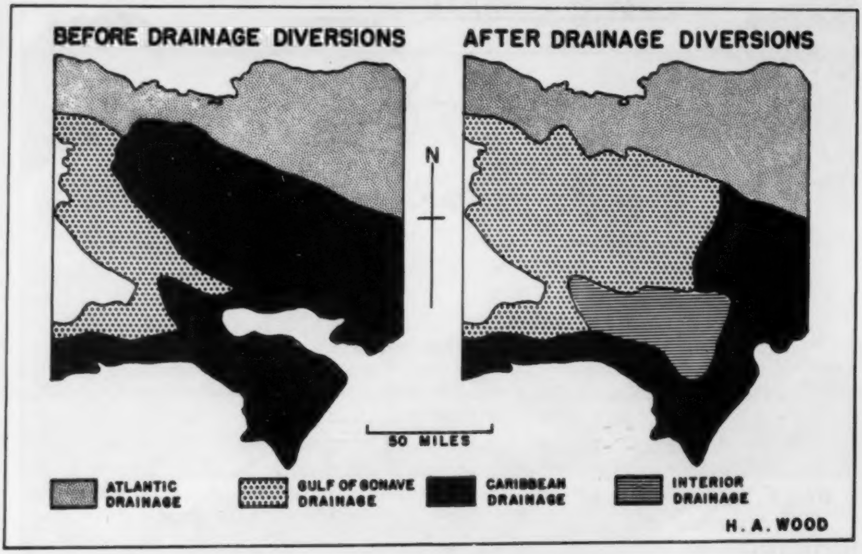

Figure 2. Central Hispaniola - Drainage Areas.

pression, which, reduced by evaporation, now forms the saline Lago Enriquillo, 44 metres below sea-level. Upon the plateau itself the diversion had little effect other than the stripping of the cover of alluvium from the eastern end of the valley, since the new outlet was not far removed in horizontal or vertical distances from the old.

All this is well known to students of Hispaniola, as is the fact of the second capture, this time by the Artibonite River in Haiti. Evidence and results of this later diversion, first noted by Tippenhauer [1] and Jones, [2] are discussed at some length by Woodring, Brown and Burbank. [3] Eroding headward along a downwarped section of the anticline which separates its valley from the Plateau Central, the Artibonite captured the drainage of most of the plateau at a point some 70 miles west of the outlet provided by the Yaque del Sur.

The consequences of this diversion have been far-reaching. Active downcutting was resumed by streams throughout the plateau, and the former covering of alluvium has been completely removed except in the extreme north, furthest removed from the point of capture, and along the divide between the new drainage into the Gulf of Gonave and the old drainage into the Caribbean. (Figures 3, 4 and 5). Softer layers of

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[1] Tippenhauer, L.G.: "Neuer Beitrag zur Topographie, Bevolkerungskunde, und Geologie Haitis", Petermanns Mitt., 55, 1909, p.53.

[2] Jones, W.F.: "A geological reconnaissance in Haiti", Jour. Geology, 26, 1918, pp.748-749.

[3] Woodring, W.P., J.S. Brown and W.S. Burbank: Geology of the Republic of Haiti, Port au Prince, 1924, p.381-382.

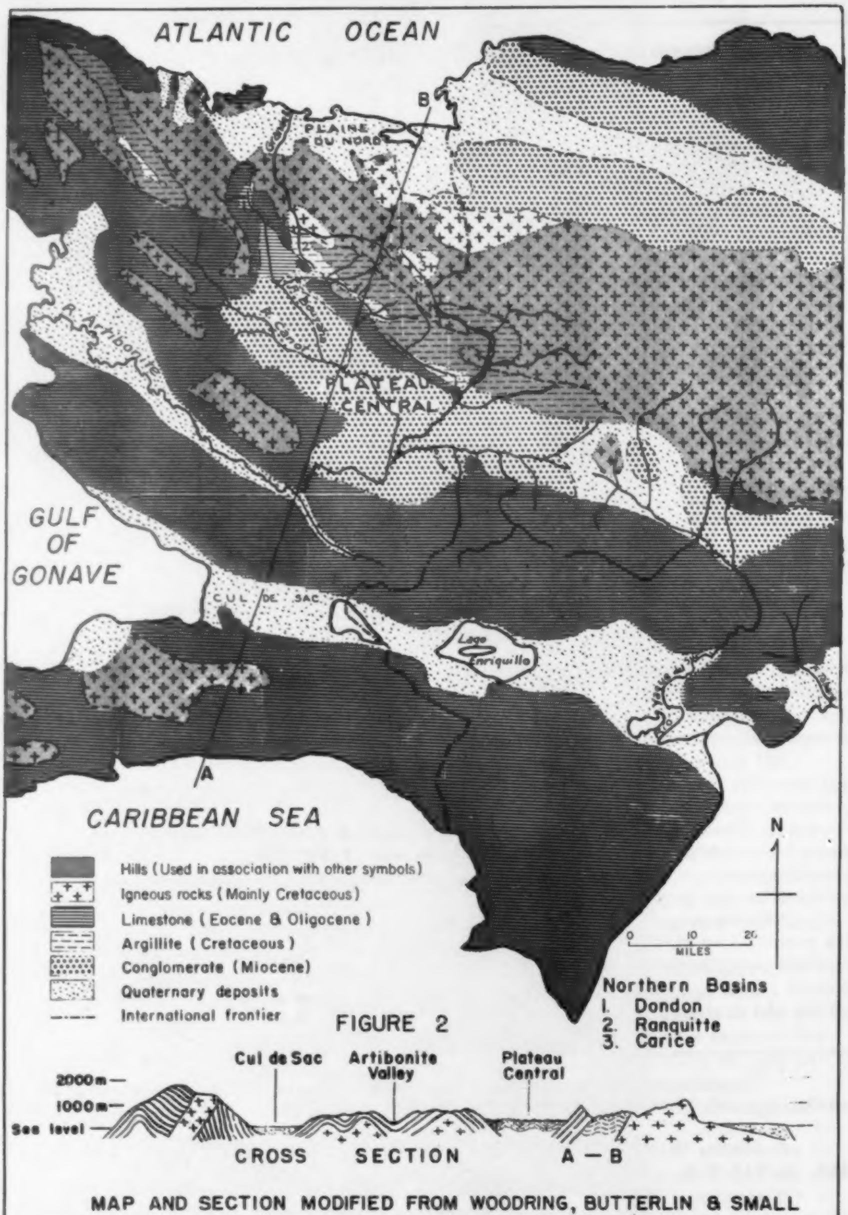

ATLANTIC OCEAN
PLAINE DU NORD
PLATEAU CENTRAL
R. Artibonite
GULF OF GONAVE
CUL DE SAC
Lago Enriquillo
CARIBBEAN SEA
B
A
N
0 10 20
MILES
Hills (Used in association with other symbols)
Igneous rocks (Mainly Cretaceous)
Limestone (Eocene & Oligocene)
Argillite (Cretaceous)
Conglomerate (Miocene)
Quaternary deposits
International frontier
Northern Basins
1. Dondon
2. Ranquitte
3. Carice
Cul de Sac
Artibonite Valley
Plateau Central
2000m
1000m
Sea level
CROSS SECTION A — B
MAP AND SECTION MODIFIED FROM WOODRING, BUTTERLIN & SMALL

FIGURE 2

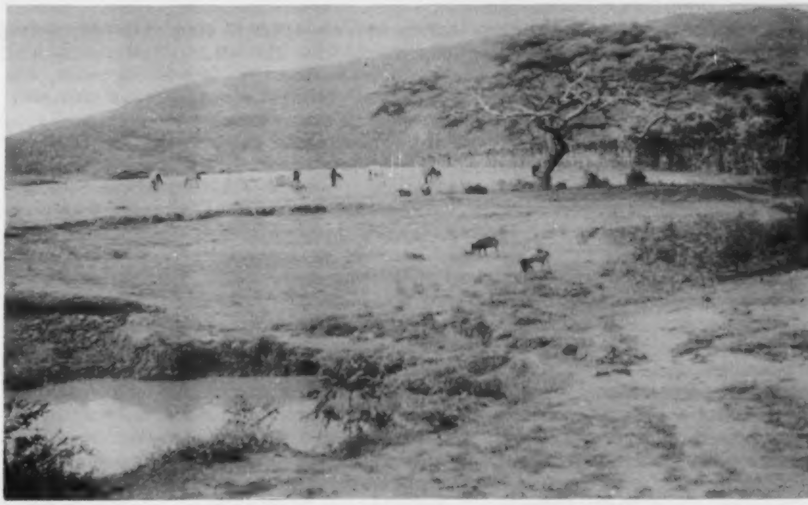


Figure 3. One of the few remnants of the alluvial plain which once covered the Plateau Central of Haiti. Lying in the extreme northeast of the plateau, this stretch of fine sandy loam is used mainly for grazing, though there are many fenced fields similar to that shown on the right of the photograph. The ridge in the background is of Oligocene limestone.

Figure 4. Undissected limestone plain near the northeastern margin of the Plateau Central. The overburden here is only a few inches thick and most of the land is used for grazing. Limestone cuestas may be seen in the middle distance and in the background.

Miocene rock have been eroded away leaving harder layers of conglomerate outcropping in accordant cuestas, to produce over most of the plateau an undulating to hilly surface. Local relief ranges from 30 feet in the north to 200 feet in the south, and little level land is to be found except in the flood-plains of streams, most of which have now resumed lateral cutting. These flood-plains represent the only easily cultivable land within much of the plateau as interfluves are so stony that they are used chiefly, though not exclusively, for pasture. (Figures 6 and 7).

From the point of view of ease of transportation the plateau has suffered, though not drastically. Streams are, if anything, less difficult to bridge than would be the case if they were more free than they now are to change course within their flood-plains. However, the steep slopes marking the boundaries of the flood-plains are serious obstacles to vehicular movement, especially since road cuts act as foci for gullying during the rainy season. For these and other reasons, although a road does cross the plateau from north to south in Haiti, it is often impassable and always hazardous for automobiles.

On the credit side it may be noted that alluvium carried by the Artibonite and its tributaries has built up along the shore of the Gulf of Gonave the most extensive plain in the Republic of Haiti. Despite its size, the Artibonite Plain has not, in the past, been very productive. Drainage is poor, the western third of the plain being a vast swamp, and over large areas soils are too saline to permit the growth of most crops. Moreover, precipitation is deficient, most of the plain receiving less than 40 inches a year while from November or December to March there is less than one inch of rain per month. Fortunately the possibility of a partial solution to the latter problem is provided by the drainage diversion through which the plain was created. The gorge cut by the Artibonite between its lower valley and the Plateau Central affords an excellent site for a dam, construction of which is now in progress, which will impound water for irrigation and which will also be used in the generation of electric power.

There remains a third important diversion from Plateau Central drainage, that effected by the Grande Rivière du Nord along the northern margin of the plateau. This has not previously been reported, as detailed knowledge of this part of Haiti was not available before the area was studied in the field by the writer and mapped by him from air photos taken by the United States Air Force in 1944. (Figure 8).

It is now evident that the area drained by the upper Grande Rivière was formerly a basin, excavated for the most part in a belt of relatively soft rock and linked by drainage with the Plateau Central. This basin, which may be termed the Ranquitte Basin, after its chief town, was one of three northern outliers of the plateau, the other two being the basins of Dondon and Carice.

At first sight it may seem strange that a major drainage diversion should have occurred in the Ranquitte Basin rather than in those of Carice and Dondon, for it is farther from the Northern Plain and receives somewhat less rainfall than either of them. Looking, however, at the geology of the area, one finds that the Dondon Basin is nearly encircled by ridges of extremely resistant limestone, so that although a tributary of the Grande Rivière eroding headward through volcanic formations has just breached the basin rim at its northeastern corner, stream piracy cannot be said actually to have occurred. At Carice the rock is somewhat less resistant, but more homogeneous, permitting erosion to proceed more uniformly. The precipitous north-facing slope of the mountain chain has been receding in a fairly straight line into the basin itself, so that the two now share a common frontage of about three miles in length. Along this divide drainage diversions have been relatively few and only small streams have been affected.

Turning now to the Ranquitte Basin, where the northern highland rim is composed of igneous rock, as at Carice, we note a significant difference. For three miles through the heart of the mountains the Grande Rivière pursues a course which is nearly perfectly rectilinear. Many rivers of the uplands exhibit a certain lineation in their

Figure 5. Rice, corn and plantains growing under irrigation on deep black clay soils of the undissected northern section of the Plateau Central.

Figure 6. Cuestas produced by the erosion of tilted Miocene gravels following the second diversion of Plateau Central drainage. The surface materials here are extremely stony and droughty and most of the land is used as rough pasture.

direction of flow due to the control exercised over their erosional activities by the attitude of the rocks through which they flow. In nearly every case, however, they describe many small twists and turns. The absence of these in a large part of the Grande Rivière gorge suggests strongly that here lies a line of fracture along which stream downcutting has been accomplished relatively easily. Clearly, therefore, rock structure is more significant than the abundance of precipitation and the width of the mountain wall in influencing stream capture across the northern rim of the Plateau Central.

The effects of these northern diversions upon the plateau proper are not very great. Two dry valleys exist forming gaps in the limestone ridge separating the plateau from the Ranquitte Basin, while the reduction in volume of some of the left bank tributaries of the Bouyaha River has made them look rather small in comparison with the valleys in which they flow. The suitability of the land for transportation and agriculture has not been appreciably affected. (Figure 9).

Within the Ranquitte Basin itself, however, the changes wrought by the piracy of the Grande Rivière are of a magnitude which can only be appreciated by a comparison with the Dondon and Carice basins, which still drain towards the south. In the two latter basins there is an undulating surface with local relief of the order of 20 to 50 feet and slopes seldom exceeding 40 per cent. Deep lateritic soils of silt loam or silty clay texture have developed which, with their good moisture-holding capacity permit cultivation through most of the year and the production of such crops as coffee, rice and plantains as well as the more tolerant corn, beans and manioc. Upon the flood-plains of the streams of these basins there is a growth of annual and tree crops which is probably unsurpassed in Haiti for luxuriance. (Figure 10).

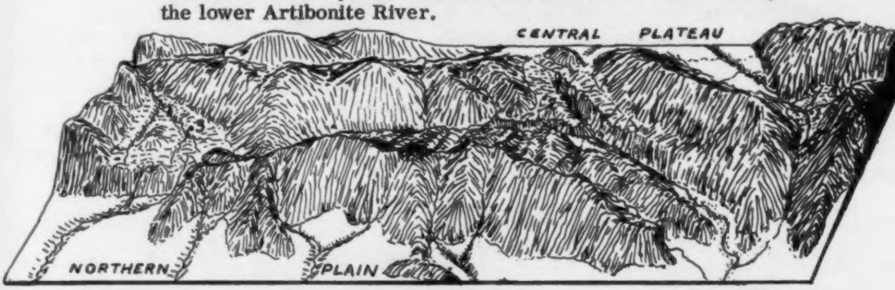
At Ranquitte, on the other hand, much of the basin floor has been intricately dissected by V-shaped gorges, some of which reach a depth exceeding 500 feet. Sixty per cent of the basin area contains slopes which are over 70 per cent, while gradients of 100 per cent are not uncommon. Even on the interfluves, where there are a few remaining stretches of relatively flat land, there is little trace of the alluvium which once covered the valley. Essentially any soil which exists is residual and juvenile. Fortunately most of the bedrock is an argillite which breaks down so rapidly that even on slopes of 80 per cent or more one usually finds three or four inches of overburden and most interfluves have a foot or more. This permits the cultivation of such crops as manioc, peas, corn, sweet potatoes and guinea grass; indeed, the proportion of the land which is under crops is no less than 70 per cent in those parts of the basin which are still only lightly dissected, though it drops to 5 per cent or 10 per cent on the steepest slopes. Yields, however, are generally low and during the dry season food shortages are common.

In that section of the basin which is underlain by volcanic rock, the high incidence of quartz results in an overburden which is thin, coarse and infertile so that agriculture is less developed than on the argillite and population is very sparse.

It is, however, in the realm of transportation that the adverse effects of drainage diversion in the Ranquitte Basin are most clearly seen. The deep gorges carved in the central section of the basin floor are extremely difficult to cross even on foot or on horseback and no attempt has been made to build a road through this area. The only road in the basin is one linking the town of Ranquitte with the Plateau Central. This road crosses a southern tributary of the Grande Rivière only two miles from its source, yet even here the stream flows in a gorge over 100 feet deep, slopes are too steep for ordinary motor vehicles and at least one jeep has been carried away by the river.

Abandoning the uplands, it is possible on foot or by horse to follow the floor of the Grande Rivière valley between the Northern Plain and the plateau. Except at times of high water, a narrow strip of alluvial gravel is exposed, now on one side, now on the other of the river, and by making a number of fordings the passage may be made

Figure 7. Cross-section of alluvial sand and gravel exposed as a result of rejuvenation of the Plateau Central drainage system following diversion of the system into the Gulf of Gonave via the valley of the lower Artibonite River.



1.- DONDON 2.- RANQUITTE 3.- CARICE

Figure 8. Northern Rim of Central Plateau of Hispaniola.

Figure 9. The valley of one of the left bank tributaries of the Bouyaha River. The stream which now follows this valley is very small since its headwaters have been captured by the north-flowing Grand Rivière .

without difficulty. The route, however, does not lend itself to road building. Apart from the danger and destruction of torrents, which fill the valley after every thunderstorm, there is the difficulty of the ascent to the plateau in the south.

In contrast, both the Dondon and Carice basins are places of entry into the highland for vehicles from the plain. Roads cross the divide at points where it is scarcely higher than the basin floors and continue southwards over easy gradients. Both routes originally extended on into the plateau proper, though the road south from Carice has been abandoned due to the low intensity of traffic.

In summary, stream capture in the Plateau Central of Hispaniola has resulted in the stripping of a fertile, moderately to well-drained alluvial covering from an area comprising some 1,000 square miles, of which 600 lie in Haiti and 400 in the Dominican Republic. This area, which could have supported fairly intensive cultivation, has been left with a surface which is hilly, stony and droughty, usable for the most part only as rough pasture, and in places very difficult to traverse.

In its stead there have been formed alluvial plains with a total area of about 500 square miles much of which can never be highly productive except as a result of expensive land improvement projects involving irrigation, drainage and the leaching away of excessive saline concentrations in the soil.

We may conclude therefore that successive drainage diversions from the Plateau Central of Hispaniola have had an over-all adverse effect on the economic potential of the island. This conclusion, of course, is of academic rather than of practical importance. The damage was done long before man appeared on the scene, and it is not likely that human efforts will prevent further inroads by north-flowing streams into the Dondon and Carice basins. Nevertheless, it is clearly evident that stream capture in this area has played a major role in the development of the geographic landscape.

Figure 10. A rice field on an alluvial flood plain in the Carice Basin. Trees in the background are mainly mangoes and bamboo.

SOIL RESOURCES AND LAND USE HAZARDS IN SOUTHERN ONTARIO [1]

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Ontario Agricultural College, Guelph

For the purposes of this discussion, Southern Ontario is that portion of the Province that lies south of the French River, Lake Nipissing, and the Mattawa River. It covers about 50,000 square miles, it is very irregular in shape and is bounded by four of the Great Lakes.

The Canadian Shield, which consists of igneous and metamorphic rocks for the most part, with little or no covering of soil, occupies the northern part of the area and extends southward to the St. Lawrence River between Kingston and Brockville. The remainder of Southern Ontario is underlain by sedimentary rocks of Ordivician, Silurian and Devonian Age.

Soil Materials

All of Southern Ontario was glaciated four times. The last glaciation (Wisconsin), however, was largely responsible for the wide variety and distribution of the surface drift from which the soils have developed. Table I shows the major kinds and extent of glacial deposits in Southern Ontario excluding the Shield area.

TABLE I

Kind and Extent of Glacial Drift Deposits in Southern Ontario
(Excluding the Shield Area)

Kind of Deposit	Acreage	% of Total
Till	7,729	40.4
Water-laid clay over till	2,500	14.4
Deltaic sand	2,316	12.1
Water-laid clay	1,983	10.3
Muck and peat	816	4.2
Recent alluvium	800	4.1
Coarse gravel	728	3.7
Shallow drift over bedrock	643	3.3
Deltaic sand over clay	622	3.2
Water-laid loam	463	2.3
Water-laid medium gravel	400	2.0
Total	19,000	100.0

1 Presented at the Fifth Annual Meeting of The Canadian Association of Geographers in Toronto, 1955.

The author gratefully acknowledges the work of the Ontario Soil Survey (Canada Department of Agriculture and Ontario Agricultural College) in making the basic soil surveys from which the statistics above were compiled.

Natural Drainage

The kind of soil parent materials, however, is only one of the factors that have influenced the soils developed in Southern Ontario. Although the maximum difference in elevation is only about 1,200 feet, the local differences in relief, particularly as they affect natural drainage, have an important effect on the soils developed.

TABLE II

Natural Drainage of Soil Materials in Southern Ontario
(Excluding the Shield Area)

Drainage	Acreage	% of Total
Excessive	666	3.5
Good	9,410	49.5
Imperfect	4,309	22.6
Poor	3,610	19.0
Very poor	1,005	5.4
Total	19,000	100.0

Climate

The climate also varies from north to south and east to west in Southern Ontario. The mean annual precipitation varies from 28 inches in the southwest to 39 inches in the east. The mean annual temperature likewise varies from 47^{o} F. in the southwest to 38^{o} F. in Algonquin Park.

Great Soil Groups

After consideration of the variations in soil materials, drainage, and climate along with variations in vegetation, it is not surprising that there are a large number of different soil types in Southern Ontario. Nearly 500 soil types have already been mapped and the soil surveys are not yet complete. It is not necessary, however, to consider all individual soil types in order to obtain a broad picture of the agricultural soil resources.

The soil profile is the fundamental basis for classification of soils. There are eight different major kinds of soil profiles in Southern Ontario.

Brown Forest Soils. The Brown Forest soils have developed in well drained or imperfectly drained high lime materials. The surface soil is dark grey-brown, about five inches thick, underlain by a brown B horizon, six to ten inches thick. The soil parent material occurs at 15 to 24 inches below the surface. Most of the soils are of medium texture and there is little variation in texture with depth in the profile.

Grey-Brown Podzolic Soils. Soils of the Grey-Brown Podzolic great soil group have also developed in high lime materials but as a result of longer time of weathering or lower original lime content, they have more horizons developed in the profile. The surface horizon is dark grey-brown, five inches thick, underlain by a grey A2 horizon, from 4 to 20 inches thick. The B horizon is reddish brown, 10 inches thick and the limey C horizon occurs at 24 to 36 inches below the surface. The B horizon contains more sesquioxides and clay than the other horizons in the profile.

Grey Wooded Soils. The Grey Wooded soils have also developed from calcareous materials under coniferous forest for the most part. They have an A_0 horizon that is more or less permanent, one inch thick. The A_1 horizon is very thin or absent under virgin conditions but the grey A_2 horizon is well developed, about eight inches thick. The B horizon is brown, 12 inches thick and the calcareous C horizon occurs at 20 to 36 inches below the surface. Unlike most of the Grey Wooded soils of western Canada, there is no distinct layer of lime accumulation in the Grey Wooded soils of Ontario. The B horizon is finer in texture than other horizons in the profile.

Podzol Soils. The Podzol great soil group consists of intensely leached soils that have developed in either calcareous or non-calcareous materials. If developed from non-calcareous materials, the undisturbed profile consists of an organic A_0 horizon, about one inch thick, underlain by an ashy grey A_2 horizon, two to four inches thick. The reddish brown B_2 horizon, 8 to 12 inches thick grades gradually into the non-calcareous C horizon.

Podzols developed from calcareous soil materials usually have a reddish brown horizon below the non-calcareous C horizon. This horizon is the fossil B horizon of a Grey-Brown Podzolic or Grey Wooded soil.

The B horizon of the Podzol contains accumulated sesquioxides but little or no accumulated clay material. The A_2 horizon may be very thin or absent in some instances but the absence of the A_2 horizon can be related to a disturbance of the soil by tree throw or removal of the forest canopy with the invasion of grass vegetation.

Dark Grey Gleisolic Soils. The Dark Grey Gleisolic soils occur in poorly drained areas in association with soils of the three great soil groups described above. The surface horizon is very dark grey-brown, five to eight inches thick, and is underlain by a mottled grey and reddish brown horizon, 10 to 20 inches thick which grades into the grey soil parent materials.

Lithosols. Soils that consist of a very thin covering, less than 10 inches, of unconsolidated mineral material underlain by hard rock are called Lithosols. Most of the Lithosols in Ontario are on igneous and metamorphic rocks although along the edges of the Canadian Shield relatively large areas of Lithosols over limestone occur.

Bog Soils. In very poorly drained areas, organic materials have accumulated in quantity to form a Bog soil. It consists of thick layers of partially decomposed plant remains underlain by mineral materials at depth varying from 18 inches to several feet. Muck and peat are in this great soil group.

Distribution of Great Soil Groups in Southern Ontario

The soil zone map (Figure 1) shows in a general way the portions of Southern Ontario in which soils of each of different great soil groups are most commonly found. There is, however, much intermixing. The Dark Grey Gleisolic soils, for example, may occur anywhere in Southern Ontario although only certain regions are dominated by these soils.

Land Use Hazards in Southern Ontario

In land use planning, it is important to recognize the natural features of the land that may restrict the use. The land use hazard map (Figure 2) shows the distribution of lands that have certain major limitations for agricultural use.

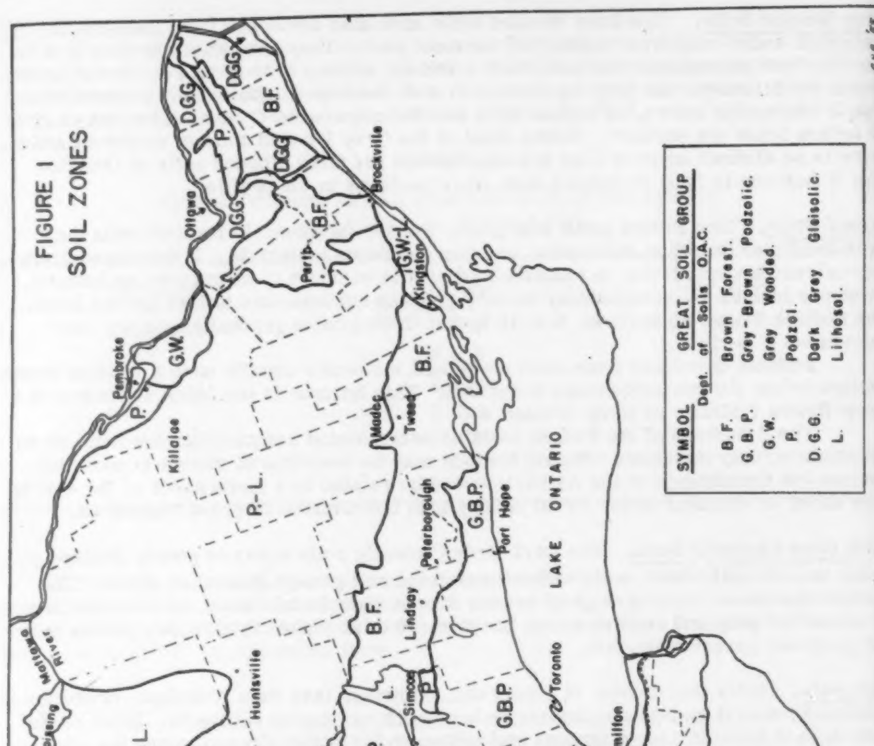
FIGURE I
SOIL ZONES
SYMBOL GREAT SOIL GROUP
Dept. of Soils O.A.C.
B.F. Brown Forest.
G.B.P. Grey-Brown Podzolic.
G.W. Grey Wooded.
P. Podzol.
D.G.G. Dark Grey Gleisolic.
L. Lithosol.
LAKE HURON
GEORGIAN BAY
LAKE ONTARIO
LAKE ERIE
Nipissing
French River
Mattawa River
Pembroke
Ottawa
Brockville
Kingston
Killaloe
Madoc
Tweed
Huntsville
Lindsay
Peterborough
Port Hope
Toronto
Hamilton
Simcoe
Barrie
Owen Sound
Walkerton
Guelph
Stratford
London
Chatham
Sarnia
Windsor
G.W.-L.
P.-L.
Partly

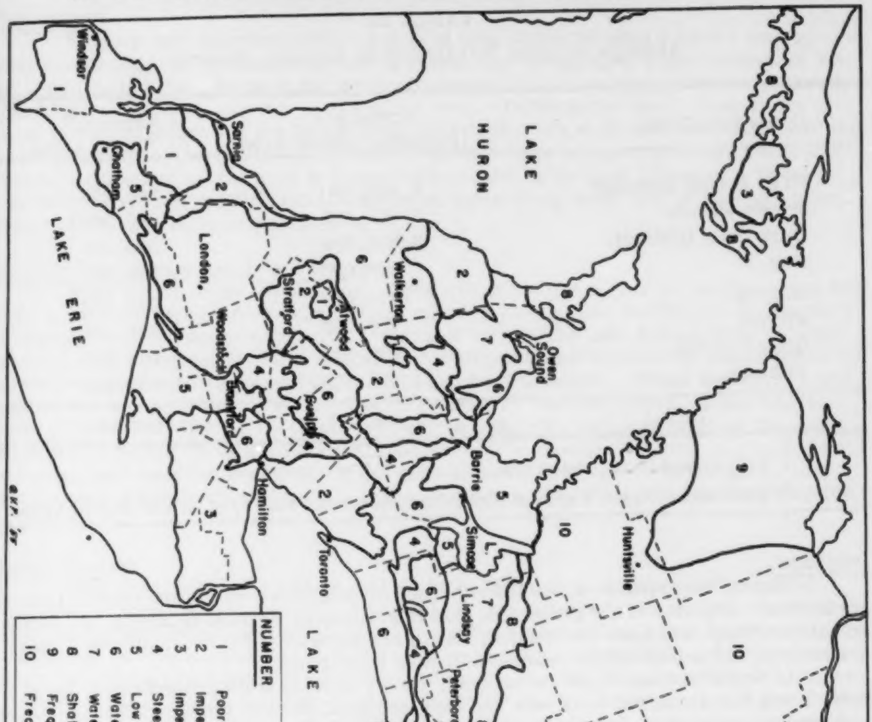

FIGURE 2
LAND USE HAZARDS

TABLE III

Acreage of Great Soil Groups in Southern Ontario

Great Soil Group	Acreage [1] (Excluding Shield Area)	Acreage [2] (In Shield Area)
Grey Brown Podzolic	9,400,000	300,000
Brown Forest	3,400,000	200,000
Dark Grey Gleisolic	3,000,000	800,000
Bog	900,000	500,000
Alluvial	800,000	500,000
Podzol	700,000	5,200,000
Grey Wooded	600,000	500,000
Lithosol	200,000	4,000,000
Total	19,000,000	12,000,000

[1] Calculated from soil maps.

[2] Estimated on the basis of small sample areas surveyed in the Shield area.

Drainage

Nearly four million acres (12 per cent) of Southern Ontario are poorly drained. No accurate estimate of the proportion that is artificially drained is available. Without tile drainage and open ditches these lands are suitable for pasture although some drainage is recommended for maximum forage production.

In areas numbered one on the map, poorly drained soils predominate, most of them being fine textured. In Essex and Kent counties, much of the land is being drained and now supports an intensive, highly mechanized cash crop agriculture. In Eastern Ontario, similar lands occur but artificial drainage has not been installed as extensively nor has mechanization proceeded as far. Numerous other areas of poorly drained soils occur in association with better drained soils. Many of these isolated areas are used for permanent pasture or trees although they could be drained if and when they are required for other farm crops.

An additional, four million acres (15 per cent) of Southern Ontario, areas number 2, have a lesser drainage problem. The imperfectly drained lands may be satisfactory for late spring crops and perhaps wheat but for alfalfa and early spring sown crops some tile drainage is necessary to carry off excess water from low-lying areas. Production per acre and variety of adapted crops can be increased appreciably on these lands by artificial drainage. At the present time, however, only a small percentage of the area has been drained.

When imperfect drainage is combined with a very heavy subsoil, the problem of drainage improvement is exaggerated as in areas 3. Slightly more than one million acres, mainly in the Niagara Peninsula have these combined hazards. Tile drainage is unsatisfactory, in most instances. Surface drainage is required in order that increased production can be achieved. Moreover, these soils are relatively low in organic matter and lime. It is not surprising therefore that the soils are difficult to work. Those who know when and how to handle these soils, however, can carry on a livestock program quite successfully.

Topography

Slightly less than one million acres of land shown as area 4 on the map are on hilly topography that restricts the use of machinery encourages water erosion if the soils are cultivated. Many of the soils are coarse in texture and, therefore, have a low moisture holding capacity and fertility level. In the early days, these areas offered good homesites and the forest gave little indication of the low adaptability of the soil. Even today most of the land in areas number 4 is occupied although there has been a decrease of 10 per cent in occupied farmland in the past 10 years. Modern machinery does not operate satisfactorily on these steep lands and so they are being retired from agricultural production.

Moisture Deficiency and Low Fertility

Even on the more level areas, there are three and a quarter million acres that have a low moisture holding capacity and either a low natural fertility or the fertility is rapidly depleted under cultivation. Areas 5 include the land and sandy loam soils in undulating topography. With adequeate fertilization and care in the maintenance of the soil organic matter content these soils can be productive. There are early soils, well suited to vegetable growing. The large area in Norfolk County, abandoned for general agriculture about 1900, has changed to a thriving community since the introduction of tobacco. It is unlikely that tobacco will or should be grown on similar soils in Simcoe and Renfrew counties. If the need arises, however, with irrigation and fertilization these lands can make a major contribution to the agricultural production in Ontario.

Water Erosion

Wherever raindrops fall on soil there is likely to be erosion. Throughout Southern Ontario, however, there are less than one million acres of severely eroded land. More than 20 million acres are moderately eroded. The areas 6 are moderately susceptible to erosion and this in fact is the major land use problem. In other words, these lands have few limitations for use. They are fertile, deep, medium to fine textured well drained soils that are durable, versatile and productive. Good crop rotations and simple management practices suffice to maintain and even increase production on these soils. More than 6 million acres (20 per cent) of Southern Ontario consists of these valuable agricultural lands on which production could be doubled without excessive cost or deterioration of the soil.

Stoniness

Although stones occur over many of the lands in Ontario, there are only about one million acres from which some stones must be removed before cultivation. Approximately 300,000 acres are too stony to be cultivated and a few additional acres are being retired from general crops in recent years because of the stoniness hazard to modern machinery such as combines. Excessive stoniness is a problem in areas 7 although there are many lands in these areas that are not excessively stony. Water erosion is a hazard here also as it was in areas 6.

Shallowness over Bedrock

There are nearly two million acres of land, largely in areas 8, on which the soil is less than three feet deep over limestone bedrock. Such soils are often excessively stony as well. They have a low moisture-holding capacity and prohibit adequate root development of the crops. With adeuqate fertilization the deeper soils can be used for general farm crops but the thin soils (800,000 acres less than 10 inches over bedrock) are used as range land for beef cattle.

Rock Outcrop

In the Canadian Shield area of Southern Ontario the igneous rock outcrop is the dominant feature. The rock presents a physical hazard to cultivation particularly with modern machinery. In areas 9, the soils are mainly imperfectly drained clays that are low in lime and organic matter. However, these soils are more productive than the sandy soils in areas 10. Both areas, however, are limited by the frequent rocks and the relatively low productivity of the soils even when they are cleared in sizeable acreages.

General

At the present time there are about eight million acres of cropped land in Southern Ontario. This represents only 25 per cent of the total area. Some good cropland, presently forested, could be brought into agricultural production. At present, however, cost of clearing is too high but the land remains as a potential agricultural resource. On the other hand, some lands presently under cultivation should be reforested because of excessive erosion, stoniness, or droughtiness. A reasonable estimate is that the present acreage of agricultural land could be increased by 20 per cent if and when the need arises. The major advances in production however will come through more effective and efficient use of the land already in production. Increases of 50 to 100 per cent in production are easily possible if present known methods of good land management were applied on all farms.

THE AERIAL RESOURCES SURVEY OF WEST PAKISTAN [1]

R. C. Hodges

Soils and Land Use Section

The Photographic Survey Corporation, Ltd.

One of Canada's major contributions to Pakistan under the Colombo Plan has been an aerial resources survey. This project, valued at $3, 000, 000, has been carried out on behalf of the Government of Canada by the Photographic Survey Corporation Limited. The program can best be envisaged if considered under the three headings of photography, geological survey, and soils and land use survey.

Photography

This includes "flying the country" to obtain complete air photo coverage and the processing of the film and its further use. The scale of the photographs is 1:40, 000 (approximately 1½ inches to one mile). This was obtained by flying at 20, 000 feet above ground level using a six-inch focal length camera. The 340, 000 square miles of photography was completed by two aircraft from our establishment in Oshawa, Kenting Aviation Limited, between November, 1952 and June, 1954. The area covered is comparable to that of the Province of Ontario (348, 000 square miles).

The film was processed and inspected in our laboratories at the company headquarters in Quetta, Baluchistan, and then sent to Toronto for the purpose of making sets of contact prints and mosaic sheets for the use of the Resources Survey staff.

Geological Survey

This consisted of the reconnaissance mapping of the age, structure, and lithology of Baluchistan, a little-known and sparsely populated area of 125, 000 square miles. Baluchistan is a most inhospitable region consisting of an arid, mountainous upland lying at an elevation of from 2, 000 to 8, 000 feet above sea-level. The task of mapping this difficult terrain would, by conventional methods, have taken 10 to 20 years to complete. However, the techniques of photo-interpretation with adequate field traverses enabled a team of ten geologists to do the work in two year. In addition the degree of accuracy attained was much greater than that possible by older methods. The equally formidable task of publishing the results of this work is now under way in Toronto.

Soil and Land Use Survey

The mapping of the agricultural resources of the vast plains of the Indus River and its tributaries, and some adjacent alluvial basins was also a project of considerable magnitude. It was planned to carry out a reconnaissance study of some 110, 000 square miles, recording the landforms, soils, and present land use in a period of eight months in the field. Here again, the maximum use of the air photos enabled us to accomplish what would have taken many years to do by conventional methods.

Perhaps the best way to explain the approach adopted and the scope of the survey would be to give a brief sketch of West Pakistan and its problems and mention how we developed a method of handling the job presented to us.

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[1] Presented at the January 1956 meeting of the Southern Ontario Division of the Canadian Association of Geographers in Toronto, Ontario.

Pakistan was born nine years ago when the Indian peninsula gained political independence and was divided into two countries. The Pakistan which emerged consisted of two provinces separated by 1,000 miles of territory of the Republic of India and connected physically only by an expensive air trip or a long sea voyage.

The province of East Bengal is different in every way from the Western province. Climate, vegetation, agriculture, and the people and their language are unrelated. Seemingly only a religious bond has held them together. Of the two parts, West Pakistan is in a more favourable position having a better balance between population and food production. Here, 35,000,000 people live on about 150,000 square miles, whereas East Pakistan has about 40,000,000 people on less than half this area.

Most of the people of West Pakistan live on the Indus Plains which are surrounded on the west by the arid mountain lands of Baluchistan, Waziristan and Afghanistan, on the north and northeast by the Himalayas, on the east by the Republic of India and the Thar Tropical Desert, and on the south by the Arabian Sea.

It was in the inhabited area of current use and potential agricultural development in West Pakistan that our survey was concentrated.

After a preliminary inspection by a Canadian Government expert accompanied by a member of the Resources Survey staff of our company, a general scheme of operation was drafted. No details of method or legends to be used was specified, fortunately, and it devolved on Ian Fraser and myself to go to Pakistan to assess conditions and design the survey.

One of the difficulties encountered at the beginning was the dearth of existing information and the poor quality or entirely unscientific nature of many of the references we did obtain. However, it had one good result in that we entered the field completely unbiased and in a position to base our judgement entirely on our own observations.

We began our investigations on the deltaic flood plain of the Indus, not far from Karachi, spending a couple of weeks there, and later made reconnaissances in a number of other localities, selected as being typical of the major regions. These initial studies were completed in three months and we returned to Toronto to appraise the findings and plan the program for the completion of the survey.

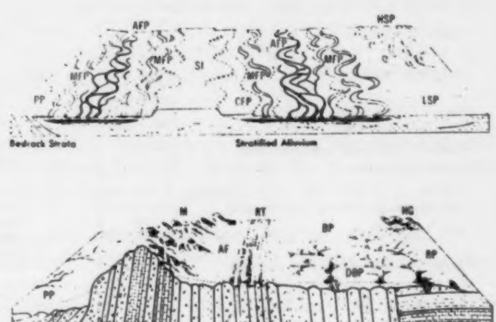
Landforms: It became apparent that landforms should form the main basis of our classification of the physical land conditions. Because of the reconnaissance nature of the survey it was necessary to use relatively large units of landscape to form mutually exclusive categories for mapping purposes. It is interesting to note that our map legend includes twenty distinct features, some of which have not so far appeared in the literature of geomorphology. (Figure 1). We have recognized, for example, six significant features on what would be termed in the textbooks as just alluvial plain.

Soils: It was discovered that the soils could not be classified and grouped into mapping units on the basis of profile development as is done in Canada. The reason for this difficulty is simply because there are no profiles! The parent materials throughout the Indus Plains are of alluvial origin varying in age from very recent to Pleistocene. But even the oldest show little or no signs of profile development because the effect of the semi arid climate in the soil forming process is at a minimum.

The differences in the soils are not great from one part of the country to another, the most noticeable feature of these alluvial soils being the stratigraphy, which varies in occurrence from very thick deposits of uniform material to thin layers of diverse materials. These types of layering depend of course on the vagaries of fluvial deposition. A systematic arrangement of these stratified materials provided us with the first element of the classification of the soils. (Figure 2).

LANDFORMS

SI	Scalloped Interfluve
CFP	Cover Flood Plain
MFP	Meander Flood Plain
AFP	Active Flood Plain
DFP	Deltaic Flood Plain
CR	Channel — Levee Remnant
BP	Basin Plain
DBP	Dissected Basin Plain
LSP	Level Sand Plain
RSP	Rolling Sand Plain
PP	Piedmont Plain
RP	Weathered Bedrock Plain
HG	Hilly Gravel Upland
RT	Ridge-and-Trough Upland
DF	Desert Fringe
HSP	Hilly Sand Plain
AF	Alluvial Fan
TD	Tidal Delta
M or R	Mountain or Exposed Bedrock
E	Severely Eroded Land



DIAGRAMS OF LANDFORMS

Figure 1.

SOIL LEGEND

STRATIGRAPHY
(0 to 4 feet)

A Profiles consisting of coarse to moderately coarse materials

B Profiles consisting of medium to moderately fine materials

C Profiles consisting of fine materials

D Profiles consisting of layers of coarse to moderately coarse and layers of medium to moderately fine materials

E Profiles consisting of layers of coarse to moderately coarse and layers of fine materials

F Profiles consisting of layers of medium to moderately fine and layers of fine materials

G Profiles consisting of layers of coarse to moderately coarse and medium to moderately fine and fine materials

FIELD TEXTURAL CLASS
(Surface Materials)

1 Coarse Materials

2 Moderately Coarse Materials

3 Medium Materials

4 Moderately Fine Materials

5 Fine Materials

PHASES

Severely saline land

Severely saline spots

Surface stones or gravel

Severe gully erosion

Predominantly poorly drained and waterlogged area

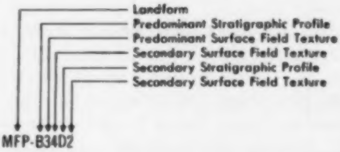
Poor drainage, Severe waterlogging Marsh, Swamp

Canal showing evidence of seepage

Sand dunes

Rock outcrop

EXAMPLE OF THE CONSTRUCTION OF A SOIL SYMBOL



The entire symbol represents a soil complex. MFP denotes that the landform is Meander Flood Plain. B34D2 represents the Soil Association. The position of B34 at the beginning of the symbol indicates that B profiles having medium to moderately fine materials are predominant and that class 3 is more common than class 4 as a surface material. Of lesser areal importance are D profiles in which layers of coarse to moderately coarse materials are interbedded with layers of medium to moderately fine materials with class 2 materials at the surface.

Figure 2.

The next significant factor was the texture of the surface soil material and this forms the second element in the classification. Together these categories form mappable soil associations within each landform. The justification for basing the whole system on the texture of the materials and their arrangement in layers is simply that the bulk of the agriculture of Pakistan is based on irrigation and the main criterion for determining the suitability of the soil for irrigation in these level alluvial plains is permeability. The permeability is a function of stratification and texture. We are in fact dealing with a soil that has no developed profile, no humus content, and is not influenced by freezing and thawing. It is a purely mineral soil, to be irrigated and cultivated in the condition in which it was laid down by the flood waters of the river.

Water: The further the work progressed the more it became apparent that the soil per se was one of the least important factors in the total scene. In an arid climate, water, of course, is the limiting factor. The distribution of the water provided by the rivers which flow through these arid plains en route from the Himalayas to the sea is governed by topography. Thus the landform assumes prime importance especially as such differences in the soils as do exist are also characteristic of the landform in which they occur.

Second only to the landform and its associated soils in importance is the ground water situation. It may seem paradoxical to say that in an arid region where water is the most valuable asset, a high water-table often creates a critical problem. One look at such a landscape immediately reveals the nature of this problem - salinity. A characteristic of most arid plains throughout the world is the presence in the soil material of a high proportion of salts, often with a high pH rating. In West Pakistan such calcium salts as Calcium Sulphate, Calcium Carbonate, etc., are common, in addition to Sodium Chloride.

A water-table within 15 feet of the surface allows capillary water to carry dissolved salts upward and to deposit them at the point of evaporation. Wherever this point is at or near the surface, the concentration of the salts inhibits plant growth. The rise in water tables in several areas of Pakistan has been induced by long years of irrigation, no provision for drainage having been made when the systems were designed and installed. We have mapped these conditions of water-logging (as it is called) and salinity as phases on our landform and soil map. Some other phases of local occurrence were recorded during the survey but they are not of sufficient importance to mention here.

I wish to stress, however, that all criteria recognized and mapped during the survey are features which can be discerned by stereoscopic examination of the photographs and, in fact, all boundaries were drawn by this means on the photographs after a thorough study of the meaning of the photo tones and patterns in the field in every region and on every kind of terrain.

The amount of detailed and accurate information which can be extracted from an aerial photograph by a skilled interpreter seems to be almost beyond belief to one unfamiliar with this technique. However, it must be understood that such a skilled interpreter must also be thoroughly trained in the field of his specialty in order to use the air photo to maximum advantage.

Present Land Use: Concurrent with the investigation of the physical land conditions in the field, extensive observations were made of the present use of the land. It was not until more than half-way through the survey that the land use legend was finalized. We purposely kept an open mind on this matter until we were sure that we had seen all the possible kinds of use and were in a position to decide which were of major and which were of minor importance.

1 SETTLEMENTS AND ASSOCIATED NON-AGRICULTURAL LANDS [1]

Urban land, airfields, military installations, industrial developments, etc.

2 HORTICULTURE

Market gardening of vegetables and fruits (Included in Class 4)

3 TREE AND OTHER PERENNIAL CROPS [3]

Orchards and groves of citrus and deciduous fruits, mangoes, dates, etc.

4 CROPLAND

Cultivated land, including fallow

- 4a PERENNIALLY CANAL IRRIGATED [4a]
  Land irrigated from canals throughout the year
- 4b SEASONALLY CANAL IRRIGATED (CONSIDERABLE WELL IRRIGATION) [4b]
  Land irrigated during high-water period by non-perennial or inundation canals; part of this land dry cropped during low-water period, part well irrigated
- 4c SEASONALLY CANAL IRRIGATED (INCONSIDERABLE WELL IRRIGATION) [4c]
  Land irrigated during high-water period by non-perennial or inundation canals; with or without dry cropping during the low-water period
- 4d SEASONALLY FLOODED [4d]
  Land seasonally inundated by river overflow; primarily winter cultivation with or without well irrigation; limited summer cropping
- 4e TORRENT WATERED [4e]
  Land dependent on torrent water guided and trapped by bunds
- 4f DRY CROPPED [4f]
  Land dependent on natural rainfall for water supply
- 4g WELL IRRIGATED [4g]
  Land irrigated from Persian or tube wells

6 UNIMPROVED GRAZING LAND

Land with natural vegetation used for grazing, browsing and fuelwood

- 6a GRASSLAND [6a]
  Land with grass cover; little or no scrub growth
- 6b SCRUBLAND [6b]
  Land with stunted tree and shrub growth
- 6c SEMI-DESERT [6c]
  Land with sparse scrub vegetation, arid, sandy

7 WOODLAND

Land producing wood for fuel or lumber

- 7a RESERVED FOREST [7a]
  Government-owned land on which cutting of trees and grazing are controlled
- 7b OTHER WOODLAND [7b]
  Natural woodland on which cutting of trees is unrestricted

8 SWAMP AND MARSH [8]

Fresh or salt water areas used for fishing, hunting and grazing

9 UNUSED LAND [9]

Presently unproductive land with or without potential productive use

EXPLANATION

The use of a colour with its accompanying symbol alone denotes an area having a single category of land use. The use of both a colour and a pattern with their accompanying symbols denotes a land use complex in which two significant categories occur in units too small to be mapped separately at the scale of this survey. The colour then denotes the predominant use and the pattern denotes the significant secondary use.

Examples

[4f] The use of this colour and symbol, without a pattern and secondary symbol, indicates that this area is entirely dry cropped.

[4f/9] The presence of both colour and pattern indicates a complex area in which the two uses (predominantly dry cropped with significant areas of unused land) cannot be mapped separately at this scale.

FIGURE 3

The classification established by the World Land Use Survey of the International Geographical Union was accepted as a basis for our classification. However, we early abandoned the system of subdivisions recommended therein as being quite unsatisfactory for West Pakistan. While retaining the main headings we formulated an augmented legend which will appear on the maps now in preparation. (Figure 3).

With the aid of the field observations, some local statistical data garnered from the Pakistan municipal offices and blue-print maps of all the irrigation systems in the country, we have mapped the land use entirely by means of photo-interpretation in Toronto. The degree of detail and its accuracy far exceeds that anticipated at the inception of the contract by the Canadian and Pakistani officials who are concerned with the outcome of our efforts. The final information which we are presenting to Pakistan will consist of 29 map sheets in the Geology series, 25 map sheets in the Landform and Soil series and the same 25 map sheets in the Present Land Use series, all lithographed in colour and accompanied by two rather voluminous reports.

OVERSEAS TRADE AT THE PORT OF TORONTO

Donald Kerr and Jacob Spelt

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A great deal of speculation has recently centred round the possible effects of an enlarged seaway on trade between Europe and various Ontario ports. The question has been asked, which of the major Ontario ports will benefit most from the seaway, and in what proportion will the trading advantages be distributed amongst the Great Lakes ports as a whole.

At the present time, Toronto, with one of the best harbours on Lake Ontario, is by far the most important Ontario port with reference to overseas trade. In this paper, prevailing trading conditions at the port of Toronto will be analyzed, and conclusions drawn as to the likely development of overseas trade at the port, in comparison with rival ports, when the enlarged seaway is in operation.

The increase in overseas trade[1] at the Great Lakes ports during the last decade is an outstanding factor to emerge from a study of trading development generally. Vessels able to navigate the Atlantic Ocean, but small enough to pass through the St. Lawrence canal system, have been exchanging an increasing amount of cargo at ports like Chicago, Cleveland, and Toronto. In contrast to the 23,568 tons of overseas cargo handled at Toronto in 1948, and the 50,222 tons handled in 1952, 120,230 tons were handled at the port in 1955. These facts are significant when studied in the light of the port of Toronto's past development.

Development of the Harbour

Toronto now possesses excellent harbour facilities (Figure 1), but when the city was founded in 1793, the outline of the harbour differed greatly from the present day. The bay was almost surrounded by a series of recurved spits, formed from debris carried westward from the foot of the rapidly-eroding Scarborough Bluffs. To the west, the only entrance to the bay was by means of a navigable channel, 1,500 feet wide and 20 feet to 30 feet deep, but a sandy shoal made an approach to this entrance difficult. The north shore of the bay consisted of a clay cliff, 12 feet to 20 feet high, which had been notched by a number of small streams. A marshy area, known as Ashbridge's Bay, through which the Don River by means of several shallow channels found an outlet into Toronto Bay, occupied the eastern portion.

An important change in the harbour occurred in 1858, when the lake broke the neck of the recurved spit to create a deep eastern channel, 1,500 feet wide. In a short time the channel was in general use. In later years, however, wave erosion widened the gap considerably, and it became necessary to take measures to protect the island. The width of the gap was accordingly reduced to 400 feet, and the flooded lands on either side filled in. This work was begun in 1882, and the last pier completed in 1927. The island no longer benefits from the debris of Scarborough Bluffs, as this debris is now caught by the eastern pier. Instead, the island is itself subject to erosion, and measures are necessary, not only to protect Toronto Bay, but also to make possible a proper use of the island.

Meanwhile, the western channel proved inadequate, several ships being wrecked. Work on a new channel, 1,300 feet to the south of the old one, began in 1908, and, in 1911, it was opened to navigation, the old channel being filled in.

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[1] Mayer, Harold M.: "Great Lakes - Overseas: an Expanding Trade Route". Economic Geography, 30, 1954, pp. 117-143.

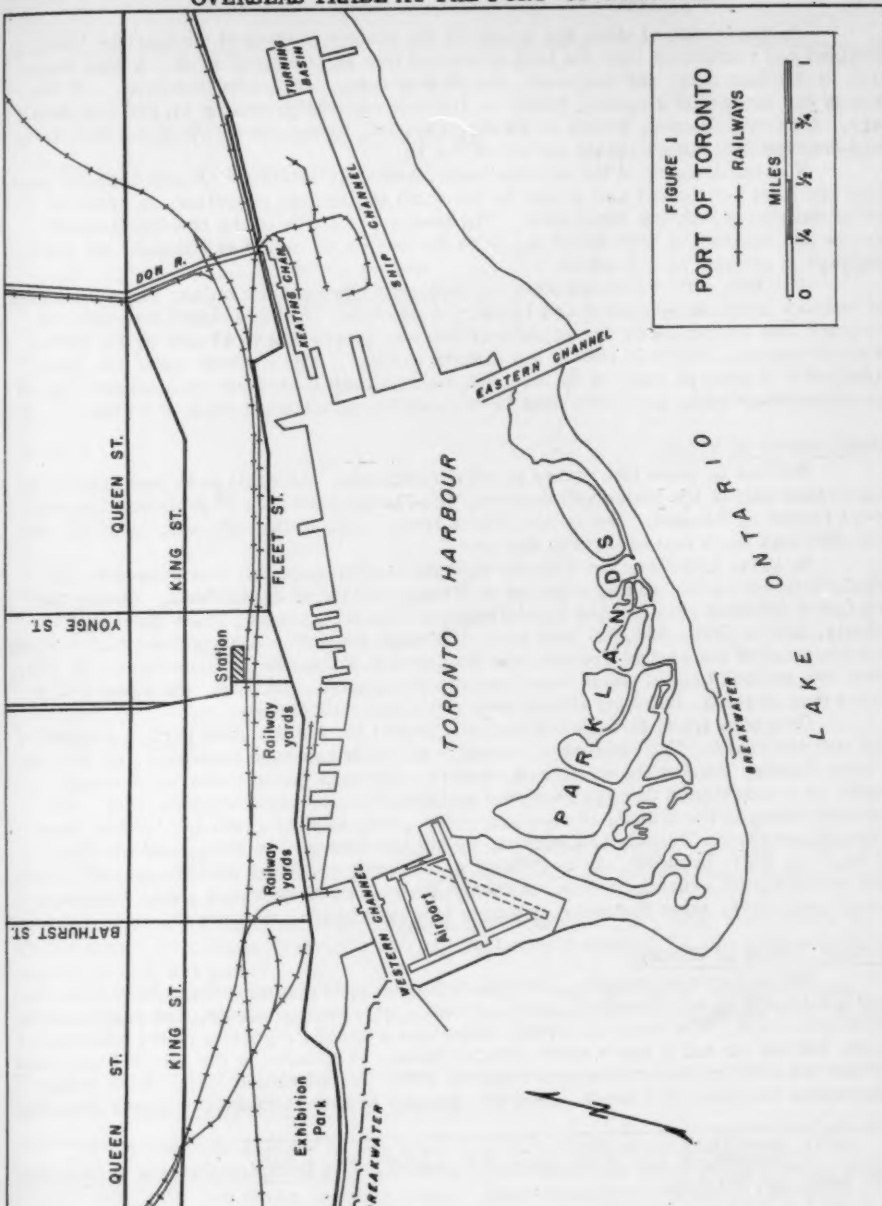
FIGURE 1
PORT OF TORONTO
RAILWAYS
MILES
0 ¼ ½ ¾ 1
TURNING BASIN
SHIP CHANNEL
KEATING CHAN.
DON R.
EASTERN CHANNEL
QUEEN ST.
KING ST.
FLEET ST.
YONGE ST.
Station
Railway yards
TORONTO HARBOUR
PARKLANDS
LAKE ONTARIO
BREAKWATER
WESTERN CHANNEL
Airport
BATHURST ST.
Exhibition Park
N

On the landward side, the marsh in the eastern portion of the bay has been drained and reclaimed, and the land converted into an industrial area. A ship channel, 6,800 feet long, 400 feet wide, and 26 feet deep, penetrates this area. At the end of the channel is a turning basin, 1,100 feet square, providing 17,000 feet dockage. A second channel, known as Keating Channel, forms the mouth of the Don River and empties into the northeast corner of the bay.

The north shore of the bay has been completely altered.[1] A new harbour headline has been built about half a mile to the south of the 1793 shoreline, in order to avoid expensive bedrock excavation. The land to the north of the new headline of moles and basins has been filled in. With the numerous moles and basins, the total dockage at present is 11½ miles.

The bay, with a present area approximately two square miles, has a foundation of bedrock overlain by glacial and lacustrine deposits. At the western channel, the bedrock lies 20 feet below the surface of the bay, increasing to 42 feet in the northeastern corner, and to 70 feet in the eastern channel. The harbour itself has been dredged to a general depth of 24 feet, the material being used for reclamation. In all constructional work, provision has been made for an ultimate depth of 30 feet.

Development of Trade

Volume of trade has varied greatly in the past. An early peak was reached in the second half of the nineteenth century, when large quantities of grain and lumber were landed at the port. But in the 1880's trade began to fall off, and, by 1912, only 340,000 tons were moved through the port.

In 1911, however, the Toronto Harbour Commission Act was passed by the Federal Government, ending a period of divided control of the harbour. During the period of efficient planning and administration thus inaugurated, trade increased slowly, and in 1929, 959,000 tons passed through the port. A significant factor in the development of the port of Toronto was the opening of the new Welland Canal. In 1931, over two million tons of goods were loaded and unloaded. By 1955, the volume had more than doubled, reaching almost four and a half million tons.

Overseas trade through the port of Toronto is, for the most part, a product of the last ten years. Until recently, virtually all trade has been coastwise, or with the United States. During the nineteenth century, overseas goods bound for Toronto would be transshipped through Montreal and Kingston, or come via New York. At various times in the history of the port, bulky goods such as grain and lumber have been shipped from Toronto to Kingston, or via the Oswego and Erie canals to New York.[2] In 1937, however, the arrival of a European vessel at Toronto opened a modern era of direct overseas trade. Although the volume of overseas goods remained small until 1946, after that year, a steady increase began. (Figure 2).

Present Trade at Toronto

On the basis of tonnage, Toronto ranks as the fifth port in Canada. Of the four and a half million tons handled, coke and coal, petroleum products, and grain are the most important. The overseas trade comprises a small proportion of the total tonnage, but ton for ton it has a much greater value. In addition to the 120,239 tons loaded and unloaded by direct overseas ships in 1955, 79,091 tons of cargo were transshipped at Montreal by Canada Steamship Lines. In both instances, imports exceeded

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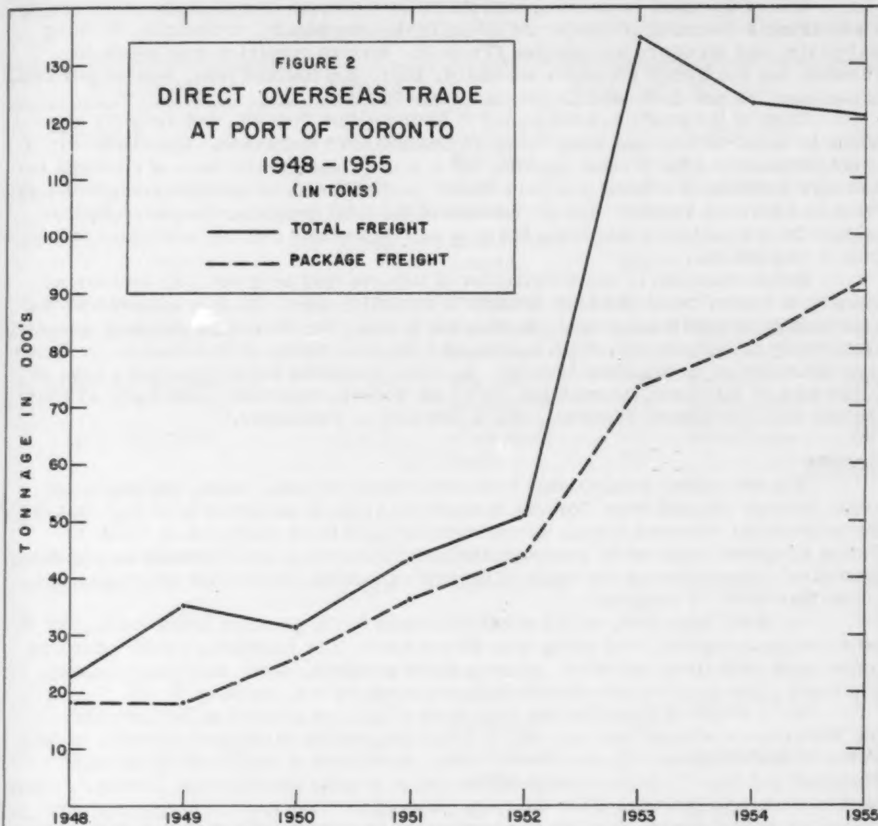
[1] Cousins, E. L.: "The Port of Toronto", The Dock and Harbour Authority, 28, 1948, pp. 107-113.

[2] Spelt, J.: Urban Development in South-Central Ontario, Assen, Van Gorcum, 1955, pp. 123-126.



exports. By direct shipments, the imports amounted to 77,631 tons, the exports to 42,608 tons. By Canada Steamship Lines, the imports totalled 72,179 tons, and the exports only 6,912 tons.[1]

In 1955, over a hundred overseas vessels,[2] representing 20 shipping lines, made regular calls at the port of Toronto. Tramp steamers from Europe also visited the port.

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[1] Toronto Harbour Master's Report, 1955.

[2] The vessels engaged in this trade look like small ocean freighters. They have a dead weight tonnage of approximately 2,800 tons, are about 250 feet long, and 42 feet wide, with two decks and four holds. Approximately three out of four have been built in the last ten years and have hulls strengthened for ice navigation. Most of them are motor ships burning diesel fuel.

Imports

One of the most interesting aspects of the overseas import trade is its variety. A remarkable diversity of goods, including foods, machinery, chemicals, building materials, and furniture are handled (Table I). Sixteen countries ship goods to Toronto, but the United Kingdom, Germany, Italy, and Holland lead, with 33 per cent, 19 per cent, 16 per cent, and 11 per cent respectively.

Most of the goods are consigned to Metropolitan Toronto, but recently shipments to south-central and south-western Ontario have increased. Unfortunately, it is not possible to give precise figures, but a survey taken in the form of personal interviews leads us to believe that over 90 per cent of the small package freight of high value is delivered locally. The percentage of the total freight consumed in Metropolitan Toronto is somewhat less, but it is safe to assume that not more than 25 per cent is shipped out.

Some examples of the distribution of imports may be given. An increasing quantity of binder twine has been brought in recently, all of which is supplied to the surrounding agricultural areas. In contrast to this, the chemicals are used almost exclusively in Toronto. Toronto has become the sole centre of distribution for European automobiles in Southern Ontario. In 1954, Canadian ports imported a total of 6,394 tons of European automobiles, of which Toronto received 1,329 tons, as contrasted with 102 tons at Montreal, and 4,528 tons at Vancouver.[1]

Exports

Exports differ considerably from imports in tonnage, value, and type. In 1955, tonnage shipped from Toronto in overseas vessels amounted to 35 per cent of the total direct overseas trade. Goods were shipped to 18 countries of which the United Kingdom received 47 per cent, Holland 20 per cent, and Germany 11 per cent. Statistical information on the value of exports is lacking, but ton for ton values are lower than those of imports.

In 1955, soya bean meal and oil accounted for 35 per cent of the tonnage of direct overseas exports, and scrap iron 25 per cent. The remaining 40 per cent was made up of such items as hides, packing house products, seed, hardwood flooring, and rags. The general lack of manufactured products was striking.[2]

Soya beans of Canadian and American origin are crusted at Toronto and, of the total export of meal and oil, only a small proportion is shipped directly, mainly to the United Kingdom. At the present time, shipments of meal and oil through Montreal and New York are considerable, but it is quite possible that Toronto's share in this trade will increase after the completion of the seaway.

In recent years, Toronto has become an important collection and distribution centre for scrap iron. Overseas exports of this commodity vary greatly, however, according to price fluctuations in the various overseas markets.

Overseas Trade at Other Ontario Ports

Many ports are situated along the Great Lakes in Ontario, but virtually all of their trade is either coastwise, or with the United States, in bulky goods such as coal, sand, or gravel. The few ports which are served by overseas vessels are located in the Lower Lakes area. (Figure 3). Excluding Toronto, Sarnia and Hamilton are the only two ports handling a significant amount of overseas trade (Table II).

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1 Canada: Dominion Bureau of Statistics, Shipping Report, 1954.

2 As an exception to this, Coleman space heaters are being shipped in increasing quantities directly from Toronto to Swedish ports. Because of the direct shipment, the space heaters do not have to be crated, and, as a result, take up less space in the hold of a ship. This saving, coupled with that of the direct water shipment, amounts to approximately $10.00 per unit, and enables the space heaters to be sold at a competitive price on the Scandinavian market.

TABLE I

Twenty-six Leading Imports, 1955

Commodity	Tonnage	Main Ports of Origin			
1. Chemicals	3,753	Manchester	1,180	Rotterdam	804
		Hamburg	722		
2. Foods, miscellaneous	3,077	Naples	1,098	Rotterdam	648
		Genoa	365		
3. Machinery	2,857	Manchester	845	Bremen	494
		London	288		
4. Nuts, edible	2,749	Hamburg	2,316		
5. Steel and steelware	2,693	Manchester	820	Gothenburg	443
		Antwerp	353	Hamburg	340
6. Glass and glassware	2,560	Bremen	883	Antwerp	541
		Rotterdam	376	Manchester	370
7. Liquor and wine	1,807	Bordeaux	607	Rotterdam	245
		Cadiz	226		
8. Sheet piling	1,621				
9. Palm oil	1,600				
10. Rope and twine	1,589	Copenhagen	1,430		
11. Earthenware	1,545	Manchester	802	Hamburg	353
12. Granite, marble and stone	1,519	Leghorn, Italy	489	Antwerp	321
		Abo	295		
13. Tiles	1,449	Hamburg	845	Manchester	547
14. Cork	1,253	Seville	473	San Selai	433
		Palamos	168		
15. Autos and auto parts	1,168	Southampton	433	Manchester	206
		London	189		
16. Tin and tinware	845	Antwerp	660	London	179
17. Lumber	785	(Very diversified, mainly Finland)			
18. Tools	716	Manchester	368	Hamburg	260
19. Iron and ironware	662	Hamburg	389		
20. Furniture and equipment	559	(Very diversified)			
21. Electrical supplies (not refrigerators or washing machines)	395	(Very diversified, mainly the United Kingdom)			
22. Cheese	393	Genoa	151		
23. Bicycles and parts	387	(Mainly the United Kingdom)			
24. Confectionary	371	(Almost entirely the United Kingdom)			
25. Fish	303	Bergen	217		
26. Wire and cable	292	Rotterdam	98	Manchester	92
		Hamburg	54		

TABLE II

Overseas Shipments at Ontario Ports, 1954

Port	Imports (cargo tons)	Exports (cargo tons)	Total
Toronto	71,056	52,103	123,159
Sarnia	4,388	35,533 *	39,921
Hamilton	11,273	14,250	25,523
Welland	nil	11,062	11,062
Cornwall	7,086	nil	7,086
Thorold	4,895	1,589	6,484
St. Catharines	2,631	nil	2,631
Kingston	nil	nil	nil
Windsor	nil	nil	nil

* 24,414 tons of the export cargo consisted of rubber and rubber products, most of which was consigned to Germany, Italy, and the United Kingdom.

Factors in the Overseas Trade at Toronto

Several factors may be suggested to explain the dominance of Toronto over other Ontario ports in the overseas trade. Of great significance is the large ready-made consumer and producer market composed of some 1,300,000 persons who make up the population of Metropolitan Toronto. Equally important is the fact that Toronto has had a long history as a collection and distribution centre. Originally the whole-sale trade grew up with the city and, for the last hundred years Toronto has dominated distribution in south-central and south-western Ontario.[1] In 1951 for example, whole-sale trade in Metropolitan Toronto reached an approximate figure of 2.7 billion dollars, or about 19 per cent of the total for the whole of Canada. Consequently, the facilities for trade have developed, and today there is in the city a large concentration of whole-salers and distributors, shipping agents, importers and exporters, customs brokers, and bankers, many of whom represent business firms established in the nineteenth century. In short, the city enjoys amenities which are unequalled elsewhere in Ontario,[2] built up by a large and varied trading and distributing fraternity.

Toronto is the focal point for rail and highway transportation in Southern Ontario and, unlike Hamilton and Sarnia which are just off the most travelled land routes, Toronto commands a central location. In terms of speed and cost of delivery, therefore, Toronto has a definite advantage over these two rivals.

Finally, the development of Toronto as a port has been speeded up by an ener-getic and resourceful harbour commission, whose contribution to the stimulation of trade must not be underestimated.[3] Integrated planning and development has been made possible by the control of the waterfront by one board, a system of administra-tion brought about by the Toronto Harbour Commission Act.

[1] Spelt, J.: op. cit., pp. 72-76.

[2] Greater Hamilton, Toronto's biggest rival, had, in 1951, a wholesale trade of $269,000,000, only 10 per cent of the Toronto total.

[3] For a discussion of port administration in general, see F. W. Morgan, Ports and Harbours, London, Hutchinson's University Library, 1952, pp. 22-25.

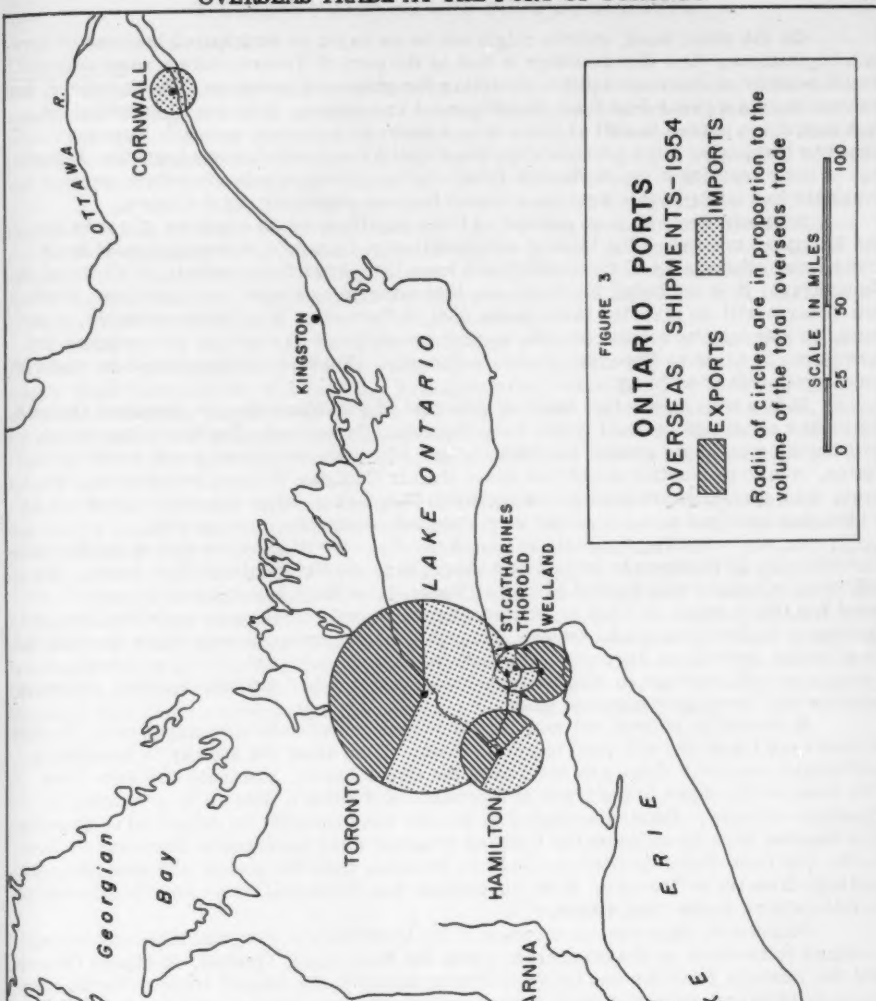
FIGURE 3
ONTARIO PORTS
OVERSEAS SHIPMENTS–1954
EXPORTS
IMPORTS
Radii of circles are in proportion to the volume of the total overseas trade
SCALE IN MILES
0
25
50
100
CORNWALL
OTTAWA R.
KINGSTON
LAKE ONTARIO
ST.CATHARINES
THOROLD
WELLAND
TORONTO
HAMILTON
Georgian Bay
LAKE ERIE
SARNIA
WINDSOR
LAKE HURON

On the other hand, growth might not be as rapid as anticipated because of certain limitations. One disadvantage is that at the port of Toronto only a relatively small number of commodities are available for shipment overseas. Furthermore, the volume varies a great deal from one shipment to another. It is a well-established fact that ships prefer to call at ports with a dependable return cargo.[1] European shipping companies have periodically investigated the possibilities of making Toronto one of their terminals but so far the relatively small and unreliable return cargo available has made such a venture unsound from an economic point of view.

Southern Ontario is at present of little significance as a source of goods for the European market. The leading commodities in Canada's overseas export trade come from other parts of the country and have their traditional outlets at Montreal or Vancouver. It is unlikely, for instance, that mineral and wood products from Northern Ontario will be diverted through the port of Toronto. It might be possible, however, to enlarge the volume of return cargo available at Toronto by encouraging the movement of grain to European ports via the city. Further studies should be made to investigate this possibility.

It is a well known fact that the high cost of manufacturing in Southern Ontario limits the export of finished goods from Toronto. In general, European importers will buy automobiles, special machinery, and other manufactured goods in the United States, where production costs are lower than in Canada. It must be admitted, however, that special trade agreements between Canada and other countries could act as a stimulus and lead to a somewhat larger export of manufactured goods.

Another limiting factor is business inertia. We discovered that many firms in Toronto plan to continue to import and export through Montreal and New York. The following comment was typical of this attitude: "Our firm has shipped through Montreal for thirty years and has had no problems; we will continue to maintain this relationship in the foreseeable future, although a slight saving in cost might be realized by shipping directly at Toronto". In certain instances, branch plants of American companies will continue to ship through New York or other American ports, following policies laid down by the parent plant.

It should be pointed out too, that Montreal has certain advantages over Toronto in overseas trade and will tend to retain them. Even after the seaway is completed, and larger overseas ships are navigating the Great Lakes, Montreal and New York will continue to share in the trade of Toronto and Southern Ontario by providing a speedier delivery. Goods purchased in Europe can presently be delivered to Toronto in a shorter time by utilising the fast and frequent liner services to Montreal or New York, and from there by truck or train to Toronto, than the slower and less frequent sailings directly to Toronto. It is our opinion that there will be no significant change in this pattern in the near future.

Moreover, Montreal as a result of its tradition and geographical location will continue to function as the point from which the Maritimes, Quebec, Northern Ontario, and the Eastern Prairies can be served most easily in the import trade. Furthermore, because Montreal enjoys through export and import rail rates, goods can be shipped by rail to and from inland cities at lower rates than through Toronto.[2]

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[1] Van Cleef, E.: Trade Centres and Trade Routes, New York, Appleton Century Co., 1937, pp. 111-115.

[2] To give an example, to ship a carload of imported window glass from Montreal to London, Ontario, a rail distance of 455 miles, costs 91 cents per hundred pounds. The cost from Toronto to London, a rail distance of 114 miles, for the same commodity, is 54 cents per hundred pounds. In short, the import rate applies from Montreal, but the domestic rate applies from Toronto.

Conclusions

Port facilities are well developed in Toronto. Ships can enter the harbour easily and the bay provides an adequate turning basin. A modern marine terminal which includes customs service is a recent development. Towards the east, because of long term planning, large tracts of land have been reserved for expansion. Physical features will not impose any limitations on the development of the port.

At an early date, Toronto emerged as the main trading centre in Southern Ontario. More than any other city, Toronto has, at the present time, the facilities for further expansion of overseas trade. It has by far the largest concentration of wholesalers and distributors, shipping agents, importers and exporters, customs brokers, and bankers. Metropolitan Toronto constitutes a large and rich market and from it, highways fan out to all parts of the province.

In the long run, it will be to the advantage of the economy of Southern Ontario that only one port specializes in the overseas trade. In this way unnecessary and costly duplication can be eliminated. Transportation rates could be lowered. In increasing numbers, ships would be able to make Toronto their Ontario terminal, thereby saving additional shipping costs by not having to sail further up the Great Lakes. Railway and trucking companies would be able to lower rates by being assured of a steady and larger volume of goods.

Direct overseas trade at the port of Toronto is a recent development. It has increased steadily and in 1954, Toronto handled 60 per cent of the total direct overseas trade at Ontario ports. The trade undoubtedly will increase after the completion of the seaway, but, because of certain limiting factors, the change will be gradual.

The position of Toronto with respect to other Ontario ports is analogous to that of Montreal [1] with respect to Toronto. Toronto will continue to outstrip other Ontario ports in the overseas trade. Furthermore, overseas vessels prefer to call at only a few major ports and for this reason, among others, more and more of the overseas trade will concentrate at Toronto. Toronto will emerge as one of the very few collection and distribution centres for the overseas trade of the Great Lakes.

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[1] For a discussion of the effects of the St. Lawrence Seaway Project on the Port of Montreal see: Camu, Pierre: "Effets du projet de canalisation du Saint Laurent sur le port de Montréal", L'Actualité Economique, 28, 1953, pp. 619-637. A translation may be obtained from the Geographical Branch, Department of Mines and Technical Surveys, Ottawa.

THE CANADIAN ASSOCIATION OF GEOGRAPHERS

PROCEEDINGS OF THE SIXTH ANNUAL MEETING

The Sixth Annual Meeting of the Canadian Association of Geographers was held in Montreal, at the Université de Montréal, from June 6th to June 8th, 1956.

Tuesday, June 5th

7:30 p.m. Meeting of the 1955-56 Executive Committee of the Canadian Association of Geographers.

Wednesday, June 6th

9:00 a.m. Registration

10:00 a.m. Business Meeting

Chairman: J. Lewis Robinson, President of the Association.

2:00 p.m. Economic Geography

Chairman: Trevor Lloyd, Dartmouth College, New Hampshire.

Gilles Boileau, Université de Montréal,
Evolution démographique de la population rural dans 60 paroisses du Québec depuis 1900.

Jean-Vianney Frenette, Université de Montréal,
Les effets du développement de la Côte Nord sur la vie économique de la rive sud du Saint-Laurent.

3:30 p.m. The Teaching of Geography

Chairman: Theo. Hills, McGill University,
Panel discussion arranged by the Chairman.

5:30 p.m. Official Reception Tendered by the University of Montreal.
Welcome by the Rector of the University of Montreal.

8:00 p.m. Joint Meeting with La Société de Géographie de Montréal and the Montreal Geographical Association.

Presidential Address

J. Lewis Robinson, University of British Columbia,
Geography and Regional Planning.

Thursday, June 7th

9:00 a.m. Physical Geography

Chairman: Roman T. Gajda, Geographical Branch, Ottawa.

Frank A. Cook, McGill University,
Additional notes on mud circles at Resolute Bay, Cornwallis Island.

J. Keith Fraser, Clark University,
Physiographic notes on features in the Mackenzie Delta Area.

Louis-Edmond Hamelin, Université Laval,
Précisions au sujet du terme ruissellement en hydrologie.

Camille Laverdière, Université de Montréal,
Essai de classification des rapides du nord-ouest du Québec.

J. Ives, McGill University,
Till Patterns in Central Labrador.

Harold Wood, McMaster University,
Stream Capture in the "Plateau Central" of Haiti.

2:00 p.m. Urban Geography

Chairman: E.G. Pleva, University of Western Ontario.

William C. Wonders, University of Alberta,
Edmonton, Alberta - Some current aspects of its urban geography.

Donald Kerr and Jacob Spelt, University of Toronto,
The Port of Toronto.

Pierre Camu, Geographical Branch, Ottawa,
Housing Characteristics in the Montreal Metropolitan Area.

Charles N. Forward, Geographical Branch, Ottawa,
The distribution of commercial establishments in St. John's, Newfoundland.

4:15 p.m. Introduction to Field Trip

5:30 p.m. Civic reception tendered by the City of Montreal at the Chalet on Mount Royal.

7:30 p.m. Meeting of the Canadian Committee of the International Geographical Union.

8:00 p.m. Meeting of the 1956-57 Executive Committee of the Canadian Association of Geographers.

Friday, June 8th

9:00 a.m. Field Trip - Richelieu Valley and Sorel

The field trip will be centred on Sorel where many industries of international and national interest are to be found. The route to Sorel will be via the scenic and geographically interesting Richelieu valley.

FIRST MEETING OF 1956-57 EXECUTIVE COMMITTEE

At the first meeting of the new Executive Committee, the following Committees were appointed with the following Chairman. Each Committee Chairman was given power to add other members.

Membership	-	J.K. Fraser
Nominations	-	J.R. Mackay
Publications	-	N.L. Nicholson
Awards	-	L. Reeds
Education	-	H.A. Wood
Programme	-	J.L. Robinson
Editorial	-	N.L. Nicholson
Constitutional Revision	-	J.B. Bird

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